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CONTENTS

The Lower Basidiomycetes of Tahiti (Continued). *Lindsay S. Olive* 89

The Comparative Anatomy and Taxonomy of Heterospyxis. *William L. Stern and George K. Brierley* 111

Another Station for Geocarpon Minimum. *Julian A. Steyermark* 122

The Separation of Chloroplast Pigments by Unidimensional Ascending Paper Chromatography. *Frederick T. Wolf* 126

Attempts to Freeze-Dry Pine Pollen for Prolonged Storage. *C. W. Hesseltine and E. B. Snyder* 134

Some Effects of Temperature on Pollen Characters. *Edwin B. Kurtz, Jr. and James L. Liverman* 136

Torreya

Elaboltzia Ciliata in New York. By Joseph Monaldino. Proceedings of the Club. Book Reviews. 139

Index to American Botanical Literature. 146

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BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 85, NO. 2, PP. 89–110 MARCH, 1958

THE LOWER BASIDIOMYCETES OF TAHITI (CONTINUED)

LINDSAY S. OLIVE

Sebacina minima sp. nov. (Fig. 14). Tenuissima, inconspicua, griseo-alba, superficie praecipue sicca sub lente minute setosa. Subiculum definitum nullum, elementa hymenialia supra hyphas indistinctas sparsa; cystidia cylindracea, hyalina, tenui-tunicata, 6.3–10 × 18–70 μ; basidia globosa vel late obovata, 6.8–9 × 7.2–9 μ; sterigmata comparate brevia, subulata; basidiosporae breviter cylindraceae vel ovatae, 3.6–4.5 × 5.9–8.1 μ.

Broadly effused, very thin and inconspicuous, grayish white, minutely pruinose under lens, drying invisible to the unaided eye, but appearing minutely bristly (by virtue of the projecting cystidia) under a lens.

Hymenial elements arising directly from the substratum and with no apparent subiculum; cystidia occurring singly, hyaline, cylindric and usually slightly tapered from base to apex, thin-walled, blunt-tipped, 6.3–10 × 18–70 μ; basidia globose to broadly obovate, 4-celled, 6.8–9 × 7.2–9 μ; sterigmata subulate, usually not exceeding the basidium in length; basidiospores short-cylindric to ovate, depressed on one side, apiculate, 3.6–4.5 × 5.9–8.1 μ, germinating by repetition.

On rotting wood of *Hibiscus tiliaceus*, Fautaua Valley, Tahiti, July 3 (T392, type).

This is another species of *Sebacina* which has fructifications too thin to permit determination of the texture. Also the hyphal development was so scant that it was not possible to determine whether clamp connections are present. The only species which has heretofore been commonly recognized as belonging to the section *Heterochaetella* is *S. dubia* (Bourd. & Galz.) Bourd., also found in Tahiti, but that species has long, slender thick-walled cystidia that arise singly or in tufts from a subicular layer. There are also differences in microdimensions. Several varieties of the species are recognized by Bourdot and Galzin (1928), one of them being var. *psilochaeta*, the only variety with thin-walled cystidia. These cystidia are emergent along most of their length and measure 5–8 × 25–32 μ. The basidiospores are oblong, laterally depressed, obliquely attenuated toward the apiculus, and measure 3–3.5 × 5–6 μ. This fungus differs from the new Tahitian species in several respects, but is obviously related to it. Although I have not examined type material of it, there seems little doubt that it is not a variety of *S. dubia* but a distinct species more closely related to *S. minima*. Therefore, the following new combination is proposed: **Sebacina psilochaeta** (Bourd. & Galz.), comb. nov.

The thin-walled cystidia of these two species are not so highly modified as are those of *S. dubia* and are probably intermediate between the gloeocystidia of the *Bourdotia* section and the cystidia of *S. dubia*.[2]

[2] The description of *Sebacina obscura* Martin (1944) by Wells (1957) indicates that it may also belong in this group by virtue of its cylindric cystidia.

[THE BULLETIN for January–February 1958 (85: 1–88 was issued March 25, 1958.]

Sebacina dubia (B. & G.) Bourd. Ass. Fr. Av. Sc. 45: 576. 1922. A single specimen of this species was found in the area. It had very thin, grayish white, soft gelatinous or soft waxy fructifications. The hymenial structure was typical, with the long, slender, thick-walled cystidia, light tan to hyaline, occurring singly and in clusters. The spores were mostly around 3.4–4.3 × 5.6–7.7 μ.

On very rotten wood of *Hibiscus tiliaceus*, Afareaitu District, Moorea, April 18.

Recently Ervin (1957) redivided *Sebacina*, recognizing the three sections of McGuire's monograph (1941) and Brefeld's subgenus (1888) *Exidiopsis* as distinct genera. However, the reasons given by Ervin for recognizing these four genera appear inadequate and unreliable, and I am therefore unable to accept her treatment of this group.[3]

There is, in connection with the classification of various groups of fungi, considerable debate as to whether the presence or absence of a single hymenial element is sufficient for the recognition of separate genera. Ervin segregates *Heterochaetella* mainly on the basis of its bristle-like cystidia with thick walls. But this does not satisfactorily accommodate *S. psilochaeta* and *S. minima*, which have cystidia that are less bristle-like and have thin walls. The fact that these cystidia are somewhat intermediate between the bristles of *S. dubia* and the gloeocystidia of the *Bourdotia* section, indicates that these two species are transitional forms linking the sections *Heterochaetella* and *Bourdotia* too closely to permit their being treated as separate genera. There are no other distinctive characters which can be consistently used to separate the two sections.

Bourdotia is segregated by Ervin on the basis of its having gloeocystidia. But, as has already been noted earlier in this paper, at least two non-gloeocystidiate species—*S. variseptata*[4] and the new *S. gloeofilum*—have conspicuous paraphyses which contain yellowish to brownish granules and which gelatinize like gloeocystidia. In the *Bourdotia* section *S. galzinii* Bres., with its filiform to clavate gloeocystidia, would seem to offer a good connecting link with these species. *S. sublilacina*, which McGuire places in his section *Eusebacina* and which Ervin places in *Exidiopsis*, has scattered to numerous thin-walled, subulate cystidia which usually project somewhat above the hymenium. Whether these structures are more closely related to the cystidia of the section *Heterochaetella* or to the gloeocystidia of the section *Bourdotia* is not certain, but their presence further complicates the task of trying to separate genera in this group on the basis of single hymenial elements.

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[3] The recent treatment of the group by Wells (1957) follows Ervin, and, therefore, the following argument applies equally to it.

[4] Ervin (1957) has presented good evidence that this species was earlier described as *Exidiopsis fuliginea* Rick, for which I propose the new combination **Sebacina fuliginea** (Rick) comb. nov.

The least tenable phase of Ervin's treatment is the segregation of McGuire's section *Eusebacina* into the genera *Sebacina* and *Exidiopsis*, primarily on the basis of texture and the presence or absence of clamp connections. In *Sebacina* she places only three species—*S. incrustans*, *S. helvelloides*, and *S. epigaea*—stating that they are tough, coriaceous, or gelatinous and lack clamp connections. In *Exidiopsis* are placed such species as *S. podlachica*, *S. prolifera*, *S. molybdea*, and *S. sublilacina*, which are said to have waxy-gelatinous to subarid fructifications and clamp connections. Certain debatable species are not treated at all.

Three different collections of *S. epigaea* described by me do not fit Ervin's description of the genus *Sebacina*. A specimen from North Carolina (1944) had continuous fructifications that were firmly waxy-gelatinous; a collection from Georgia (1947) had fructifications varying from small separate pustules to a continuous layer and gelatinous in texture; a collection from Louisiana (1948) had fructifications composed of small waxy-gelatinous pustules. It is true that clamp connections have not been reported in this group, but this feature has repeatedly proven inadequate in separating species. Certainly it should not be considered of generic importance. Of the species placed in *Exidiopsis*, it has been noted that collections of *S. podlachica* and *S. molybdea* may lack clamp connections (Olive 1947). Furthermore, the texture of *S. podlachica* is quite variable and occasionally this species has fructifications in the form of small separate pustules, as is sometimes true of *S. epigaea*. *S. prolifera* Rogers (1936) has fructifications described as mucous-gelatinous rather than waxy-gelatinous. It is my conclusion, therefore, that, in the interest of recognizing what appear to be natural relationships in this group and to facilitate the determination of species, it is advisable to retain McGuire's concept of the genus *Sebacina* with its three sections.

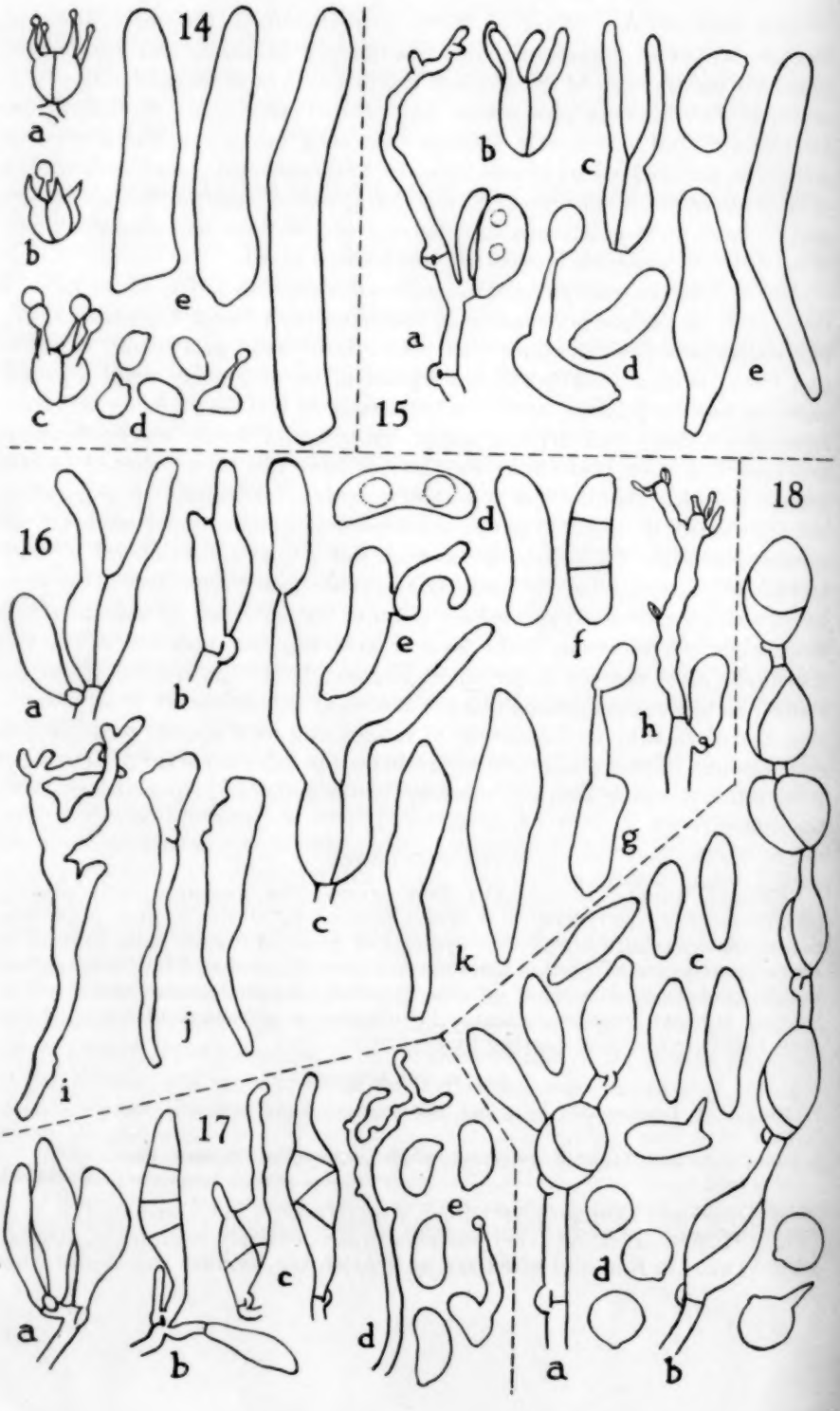
HETEROCHAETE

Effused, adnate, occasionally free around the margins, coriaceous to gelatinous, 2-layered; hymenial layers pierced by sterile hyphal pegs, containing basidia and paraphyses; cystidia or gloecystidia, or both, present or absent; subhymenial layer of interlaced or parallel, seldom-branched hyphae; basidia globose to somewhat clavate, typically 4-celled, sometimes 2-celled, bearing tubular protosterigmata; basidiospores suballantoid to reniform, more rarely ovate, germinating by repetition.

KEY TO THE SPECIES

1. Margin of fructification thin and indeterminate; spores mostly less than 16 μ long ..... *H. shearii.*
1. Margin distinct, typically becoming reflexed, spores mostly more than 16 μ long ..... *H. delicata*

Heterochaete shearii (Burt) Burt. Ann. Missouri Bot. Gard. 8: 377. 1921. (Fig. 15). Fructifications very variable in size, entirely resupinate, 100–200 μ thick, margin thin and often tan or grayish tan, texture soft fleshy when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moist, 2-layered, with a hyaline hymenial layer pierced by sterile hyphal pegs measuring 39–125 × 132–250 μ, and a yellowish-brown subhymenial layer of variable thickness, but generally thinner than the hymenial layer. Hyphae with clamp connections; paraphyses branched and tortuous; gloeocystidium-like structures scattered through hymenium, mostly irregularly clavate, sometimes fusiform, hyaline, 6.3–9 × 25–54 μ; basidia ovate to broadly clavate; 7–10.8 × 10–17 μ, usually 2-celled, occasionally 4-celled; basidiospores curved-cylindric, apiculate, 4.5–6.8 × 12.6–18.9 μ, germinating by repetition.

Common on corticate and decorticate dead limbs, frequently still attached to tree, including *Hibiscus tiliaceus* and other leguminous trees; Tahiti.

There appear to be no important differences between the above description and that of Bodman (1952). The upper limit of spore length in the Tahitian material is 18.9 μ, but relatively few spores are this long, the majority being under 16 μ.

The structures referred to here and by Bodman as gloeocystidia may be somewhat intermediate between gloeocystidia and cystidia. They are hyaline and apparently do not become yellow or orange. In the Pacific area, *H. shearii* has previously been reported in Hawaii and Guam.

Heterochaete delicata (Kl. ex Berk.) Bres. Hedwigia 53: 77. 1912. (Figs. 2B and 16). Like the foregoing species, this fungus is common in Tahiti, often growing on the same limbs with *H. shearii*. A description of the South Pacific collections follows.

Fructifications 275–470 μ thick, at first adnate out to the distinct, often lighter margins, becoming partially reflexed to almost completely free from the substrate, coriaceous, tan, often with faint pinkish or purplish tints, becoming brown where bruised; sterile brownish pegs of hyphae piercing the hymenium, 39–117 × 195–234 μ; fructifications 3-layered, composed of a pale hymenial layer, a central yellowish brown layer (the thickest), and an abhymenial, darker brown thin layer with long brownish hairs projecting from the surface. Hyphae with clamp connections; paraphyses branched and tortuous, relatively broad, the short tip branches often gelatinizing, intergrading with the cystidia; cystidia scarce to moderately abundant, typically stalked-fusiform, but variable, 6–10 × 23–42 μ; basidia pyriform or clavate, entirely 2-celled or 2–4-celled; basidiospores narrow-cylindric and curved, distinctly apiculate, 4.8–7 × 18–29 μ.

Common on corticate and decorticate parts of dead limbs that are often

FIGS. 14–18. Tremellales of Tahiti. FIG. 14. *Sebacina minima*. a–c, basidia producing spores. d, basidiospores. e, cystidia. FIG. 15. *Heterochaete shearii*. a, paraphysis and probasidium. b, 4-celled basidium. c, 2-celled basidium. d, basidiospores. e, gloeocystidium-like structures. FIG. 16. *Heterochaete delicata*. a–c, basidia. d, two basidiospores. e, basidiospore with germ tube. f, septate basidiospore. g, basidiospore germinating by repetition. h, paraphysis. FIG. 17. *Patouillardina cinerea* var *minor*. a–c, stages in basidial development. d, paraphysis. e, basidiospores. FIG. 18. *Sirobasidium magnum*. a, basidium with protosterigma attached and probasidium above. b, six basidia in a series. c, protosterigmata, one with spicule. d, basidiospores, one germinating by repetition. (All figures × 925)

still attached to the tree, including *Eugenia jambolana*, several leguminous trees, and a shrubby *Hibiscus;* Tahiti, Bora-Bora.

The material is identical with an earlier collection (Seurat) from Tahiti determined by Bodman (1952) as this species. The tendency of the fructifications to become reflexed and the presence of fusiform cystidia are important diagnostic characters. Even though they may be rare in some fructifications (probably the older ones), a few cystidia may generally be found near the margins.

If I were convinced that the resupinate versus non-resupinate character were of prime importance in this group, I would not hesitate to transfer *H. delicata* to *Eichleriella*, which has fructifications that vary from cupulate to broadly effused with free margins. However, it seems likely that the presence of hymenial pegs is of greater importance here and that such resupinate-reflexed species of *Eichleriella* as *E. macrospora* and *E. spinulosa*, which have hymenial pegs, would be more at home in *Heterochaete*. Actually, *H. delicata* and *E. spinulosa* are so similar in appearance that a careful microscopic examination is needed to distinguish them. Bodman, in addition, points out the great similarity between *E. spinulosa* and the reflexed *H. livido-fusca*. It is, therefore, not possible to draw a line of distinction between *Heterochaete* and *Eichleriella* in Bodman's treatment. A further study of the relationships of these two genera is needed.

PROTODONTIA

Resupinate, margins indeterminate, waxy-gelatinous, the hymenium covering soft spine-shaped extensions of the fructification; basidia subglobose to ovate, cruciately septate; protosterigmata relatively short; basidiospores subglobose or oval to short-cylindric, germinating by repetition.

Protodontia uda Höhn. Sitzungsb. k. Akad. Wiss. Wien, Math.—Nat. Kl. I, 116 : 83, 1907. The single collection is in every respect typical of the species. On rotting wood, probably of *Hibiscus tiliaceus*, trail to Cascades, Pirae District, Tahiti, April 6.

EXIDIA

Fructifications tender gelatinous to very firmly gelatinous, varying from hemispherical pustules to foliose or pileate; branched paraphyses usually present; gloeocystidia present in a few species; basidia cruciately septate, producing tubular protosterigmata; basidiospores allantoid to reniform, rarely varying to ovate or short-cylindric.

Although the genus appears to be a large and probably heterogeneous one, sometimes showing close affinities with *Sebacina* and intergrading with *Tremella*, I would again question the advisability of segregating these fungi into different genera solely on the basis of the presence or absence of a single hymenial element such as gloeocystidia. Therefore, I am not inclined

to accept the genus *Gloeotromera* Ervin (1956), recently erected to include the two gloeocystidiate species, *Exidia alba* and *Tremella pululahuana*. Another problem is found in the attempt to separate *Exidia* and *Tremella* mainly on the basis of spore form, a character which is considered of no such importance in the classification of most other jelly fungi. The occurrence of several species with intergrading spore types complicates the issue. A satisfactory taxonomic treatment of this complex group can be arrived at only through a thorough knowledge of the many species included in it.

Neither of the two Tahitian species of *Exidia* can be considered typical of the genus. They both have relatively inconspicuous fructifications that are pustulate at origin and spores that intergrade between the *Exidia* and *Tremella* types.

KEY TO THE SPECIES

1. Majority of basidia 2-celled, basidiospores 5.7–10.4 × 11.7–18.9 μ ..... *E. rolleyi.*
1. Basidia 4-celled, basidiospores 3.8–6.8 × 8.4–14.8 μ ..... *E. tremelloides.*

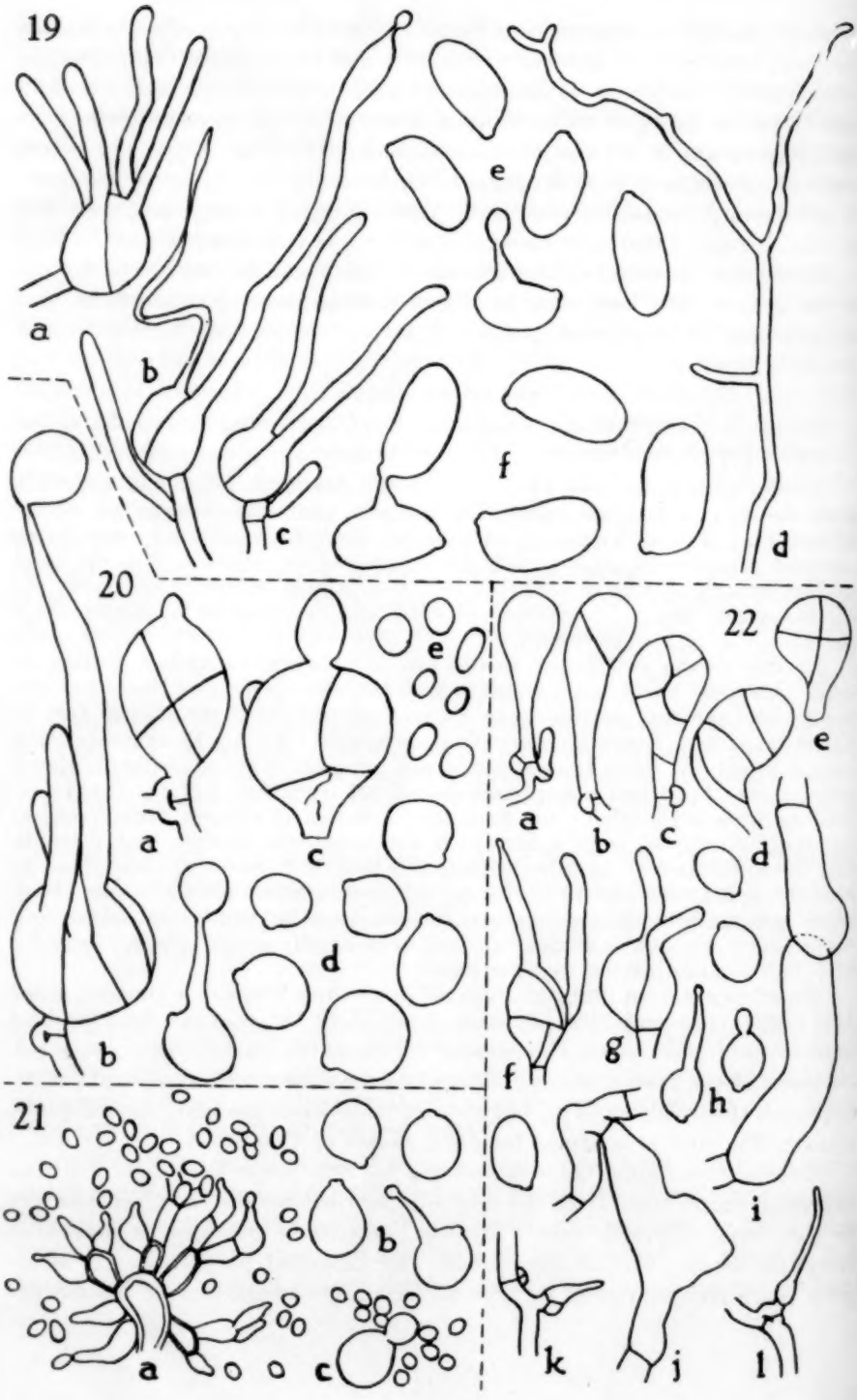
Exidia rolleyi sp. nov. (Fig. 19). Fructificationes gelatinosae, sordide alutaceae, pustulatae vel in massas nodosas, contortas marginibus determinatis, ad 2 mm. crassit. coalescentes. Hyphae enodosae; paraphyses ramosae, irregulares, multae; basidia subglobosa vel obovata, 2–4-cellularia vel bicellularia tantum, 9.9–13 × 11.7–17.6 μ; basidiosporae cylindraceae vel nonnumquam late cylindraceae vel subovatae, uno latere applanatae vel curvulae, 5.7–10.4 × 11.7–18.9 μ.

Fructifications gelatinous, sordid tan to brownish or amber, arising as small pustules, 0.5–3 mm. diam., which remain distinct or coalesce into bumpy or contorted masses up to 3 cm. long and 0.4–2 mm. thick, free to partially adnate beneath, margins determinate, drying to inconspicuous orange-brown to dark brown, vernicose patches. Hyphae without clamp connections; branched paraphyses abundant, irregular, 1–2.3 μ diam., extending in a layer above the basidia; in better developed fructifications becoming encrusted with a brownish substance, the basidia embedded in this brownish layer; basidia entirely 2-celled or 2–4-celled, subglobose to broadly ovate, 9.9–13 × 11.7–17.6 μ; protosterigmata usually quite long, often gradually enlarged above; basidiospores typically cylindric and flattened on one side or slightly curved, occasionally nearly ovate, 5.7–10.4 × 11.7–18.9 μ, germinating by repetition.

On corticate dead limbs of *Eugenia jambolana*, Punaauia District, June 11 (T322, type) and Pirae District, June 12 (T332, cotype), and on dead bark of unidentified tree, Punaauia District, June 20; Tahiti.

Some of the fructifications, attached to the substratum at several points, approach the *Sebacina* type, but even in these cases the margins are determinate. The species is named for John Rolley of Tahiti.

Exidia tremelloides Olive. Mycologia 43: 682. 1951. The single Tahitian collection varies little from the original description. The fructifications are in the form of small, nearly hyaline, gelatinous pustules or somewhat irregular masses, 0.7–2.5 mm. broad. The branched paraphyses are somewhat more irregular than in type material. The characteristic basidia are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continuous with a stalk-like base, at the lower end of which is a clamp connection. The basidiospores are short-cylindric to cylindric, straight and flattened on one side to moderately curved, measuring 3.8–4.7 × 9–11.7 μ, and germinating by repetition.

On corticate dead limb of *Mangifera indica*, Punaauia District, Tahiti, June 15.

This species has previously been found to be common in Louisiana.

TREMELLA

Fructifications tender-gelatinous to firmly gelatinous; pustulate, cerebriform, lobate, or foliose; paraphyses frequently lacking, present in some species; basidia usually 4-celled, cruciately septate, septa frequently oblique to transverse in some species; protosterigmata tubular; basidiospores globose to broadly ovate, germinating by repetition.

KEY TO THE SPECIES

1. Pustulate to cerebriform 2
1. Lobate to foliose 6
2. Hyaline or whitish in color 3
2. Orange-brown, brown, or nearly black 4
3. Light grayish hyaline; spores typically "jug-shaped," 7.7–15 × 9–15.3 μ ... *T. acaciae.*
3. Grayish white; spores subglobose to broadly ovate, 7.8–9.5 × 9.9–11.7 μ *T. carneoalba.*
4. Color orange ..... *T. cinnabarina.*
4. Color brown to nearly black 5
5. Duplex, purplish brown to purplish black, discoloring the substratum purplish ..... *T. moriformis.*
5. Not duplex, brown to nearly black, not discoloring the substratum ..... *T. boraborensis.*
6. Color white to orange-yellow 7
6. Color reddish brown to brown 8
7. Color white ..... *T. fuciformis.*
7. Color orange-yellow ..... *T. cinnabarina.*
8. Color typically reddish brown, varying to brown, gyrose-folded to erect and foliose, less than 1 cm. high ..... *T. rufobrunnea.*
8. Color yellowish brown, erect with thin foliose lobes, typically larger. *T. frondosa.*

Tremella acaciae sp. nov. (Fig. 20). Gelatinosa, griseo-hyalina, corrugata vel cerebriformis, ad 1.5 mm. alt., 1–10 mm. lat. Hyphae conspicue nodosae; basidia globosa vel ovata, 4-cellularia, septis frequenter eccentris, 15.3–23.4 × 18–28 μ; basidiosporae subglobosae, aliquando quam longae latiores, 7.7–15 × 9–15.3 μ; conidia e basidiis, sterigmatibus, basidiosporis gemmarum modo producta, 2.4–6.3 × 5–12.2 μ.

Fructifications tender gelatinous, corrugate to cerebriform, light gray-

FIGS. 19–22. Tremellales of Tahiti. FIG. 19. *Exidia rolleyi.* a, 4-celled basidium. b, c, 2-celled basidia. d, paraphysis. e, f, basidiospores of two different collections. FIG. 20. *Tremella acaciae.* a, septate basidium. b, basidium producing spores. c, basidium budding out conidia. d, basidiospores. e, conidia. FIG. 21. *Tremella carneoalba.* a, hymenial conidia produced by phialide-like structures. b, basidiospores. c, basidiospore budding out conidia. FIG. 22. *Tremella boraborensis.* a–g, stages in development of basidia; note 2-celled basidia (b, g). h, basidiospores, one germinating by repetition and one budding out conidium. i, j, swollen hyphal cells. k, l, hyphal appendages. (All figures × 925)

ish hyaline, or with faint tan or pinkish tints, 1–10 mm. broad, the larger ones, probably resulting from confluence, up to 1.5 mm. high, drying to an inconspicuous, horny film. Hyphae with conspicuous clamp connections, 1.8–4 μ diam.; paraphyses lacking; basidia globose to ovate, 4-celled, with septa arranged at all angles, 15.3–23.4 × 18–28 μ; protosterigmata variable in length, often quite long; basidiospores subglobose to "jug-shaped", occasionally broader than long, prominently apiculate, 7.7–15 × 9–15.3 μ, germinating by repetition; narrowly elliptic or cylindric to subglobose conidia budded out by basidia, protosterigmata, and basidiospores, 2.4–6.3 × 5–12.2 μ; no hymenial conidia observed.

On dead corticate branches of *Acacia*, Punaauia District, May 21 (T268, type), and on dead corticate limb, Harrison Smith Estate, Aug. 10 (T447); Tahiti.

The species most closely related to this is probably *T. carneoalba* Coker (1920), from which it differs mainly in its larger microdimensions and the shape of its basidiospores, which are frequently broadly "jug-shaped." This latter term was used earlier by Coker, and I have adopted it here for lack of a better one.

Tremella carneoalba Coker. Jour. Elisha Mitchell Soc. 35: 146. 1920. (Fig. 21). The flattened, grayish white, soft gelatinous fructifications have a convoluted surface, free margins, and are separable from the substrate. They measure about 3–12 mm. in length and 1–1.5 mm. thick. The hyphae are broad, 1.8–8 μ diam., have clamp connections at the septa, and are frequently thick-walled (gelatinization?). Paraphyses are lacking. The basidia measure 9.5–17.5 × 13.5–31.5 μ and frequently have oblique to transverse septa. The subglobose to broadly ovate basidiospores measure 7.8–9.5 × 9.9–11.7 μ and may germinate by repetition or bud out subglobose to ovate conidia. Hymenial conidia are also present and are produced on phialide-like cells. They are broadly to narrowly ovate and measure 1.8–3.6 × 2.5–5 μ. The conidial hyphae are mixed with the basidial hyphae.

On dead corticate wood of *Hibiscus tiliaceus*, trail to Cascades, Pirae District, Tahiti, April 8.

The Tahitian collection closely resembles a collection from Georgia (Olive 1947) and the description by Coker (1920). However, hymenial conidia apparently have not previously been found in this species.

Tremella moriformis Berk. Out. Brit. Fungol., p. 287. 1860. This species is readily recognizable from its mulberry-like, dark purplish brown fructifications that discolor the substrate. The fructifications are duplex and have an arid purplish core.

On corticate and decorticate limbs of *Citrus limetta*, Raiatea, May 7; also between Taravao and Tautira, Tahiti, June 27.

Tremella boraborensis sp. nov. (Figs. 2A and 22). Fructificationes substantia elastico-gelatinosae vel cartilagineo-gelatinosae, brunnea vel fusca, convoluta, minores in majores coalescentes, 1–6 cm. long., 2–10 mm. crassit. Hyphae aut nodosae aut enodosae, cellulis saepe conspicue inflatis; basidia late obovata, oblonga, vel pyriformia, 2–4-cellularia, septis fre-

quenter eccentris, 9–12.6 × 14.4–29.7 (– 35) μ; basidiosporae ovatae, 5.1–8.1 × 8.1–10.8 μ.

Fructifications rubbery gelatinous to cartilaginous gelatinous, brown to nearly black, convolute with some hollow gyrose folds and lobes, in patches up to 1–6 cm. long and 2–10 mm. thick, occasionally attached, drying to horny black masses. Hyphae 0.8–6.3 μ diam., some swollen cells up to 15.3 μ diam. (T240), basidial and smaller subhymenial hyphae with clamp connections, larger subhymenial hyphae more frequently lacking clamp connections, small bulbous structures with slender, simple or branched filament often associated with clamp connections; basidia typically with stalk-like base and broadly obovate to pyriform sporogenous portion, 2–4-celled, septa often oblique to transverse; 9–12.6 × 14.4–29.7 (– 35) μ; protosterigmata very variable in length and in order of appearance on the basidium; basidiospores ovate, apiculate, 5.1–8.1 × 8.1–10.8 μ, germinating by repetition or budding out oval conidia.

On corticate and decorticate limbs of *Eugenia jambolana*, Punaauia District, Tahiti, April 25 (T219, type); Bora-Bora, May 3 (T240, cotype).

The older hyphae, basidia, and basidiospores become orange-yellow to yellowish brown. The newer basidia and spores are tinted a light yellow. In one (T240) of the two collections, some of the swollen hyphal cells are orange in color and often strikingly resemble gloeocystidia. In the same collection a large number of conidia were present, but their origin could not be determined.

Tremella fuciformis Berk. Hooker's Jour. Bot. 8: 277. 1856. This is the only large white *Tremella* that was found in the area. The fructifications are foliaceous and much crisped and undulate along the edges of the thin lobes. Some of the larger ones measure up to 6 cm. broad and 4 cm. high. The broadly ovate basidiospores measure around 4.1–5.8 × 6.6–8.3 μ.

In this area, the fructifications of *T. fuciformis* are quite often parasitized by a sphaeriaceous or phomaceous fungus with black fruiting bodies (T55 and T290), the venters submerged in the tissue of the *Tremella* and the long necks protruding like black setae when viewed under a lens. Some fructifications are only partly infected, or both infected and uninfected ones may be found side by side. I have not been able to determine whether the parasite is a *Ceratostomella* or a longirostrate member of the Phomaceae.

Kobayasi (1939a) described a new genus, *Nakaiomyces*, which he found to resemble *Tremella* in every respect except for the presence of dark "setulae". It is obvious from his illustrations and from my Tahitian material that he was dealing with fructifications of *Tremella* infected with the same or a similar parasite. *Nakaiomyces* is, therefore, not a valid genus.

Very common on corticate and decorticate dead limbs; Tahiti, Bora-Bora.

Tremella cinnabarina (Mont.) Pat. Essai Taxonomique, sur les familles et les genres des Hyménomycètes, p. 21. 1900.

According to R. J. Bandoni (personal communication), who has ex-

amined type material of the species (*Naematelia cinnabarina*), *T. samoensis* Lloyd (1919) is a synonym. It was first discovered in Tahiti and has also been reported in Samoa, China, Japan, and the Philippines. The fructifications of my collection are bright orange-yellow, faded in older parts, with several upright, branched lobes that are generally somewhat flattened and undulate or crisped. They measure 0.7–2 cm. broad and 0.5–1 cm. high and become reddish brown or orange-brown on drying. The hyphae have clamp connections and are mostly thick-walled; the basidia are 4-celled and occur in a rather narrow zone at the surface of the fructification; the basidiospores, which are broadly ovate, measure 4.5–6.1 × 6–8.6 μ and frequently bud out oval conidia or, less frequently, germinate by repetition. No hymenial conidia were observed. Many of the hyphae and older basidia become bright orange-yellow.

On decorticate wood of *Inocarpus edulis*, Harrison Smith Estate, Papeari District, Tahiti, June 13.

Tremella rufobrunnea Olive. Mycologia 40: 591. 1948. The two Tahitian collections are in no essential way different from the type material from Louisiana. The fructifications are gyrose to upright and foliose, up to 8 mm. high and 11 mm. broad. Some contain only conidia and sterile vesicles, with yellowish walls that become gelatinous-thickened, while others contain basidia in addition. In some fructifications the basidia are abundant and the conidia and vesicles less so. The oval basidiospores measure 6.3–8.6 × 9–12.6 μ. The species appears to be most closely related to *T. lutescens*.

On dead corticate limbs of *Acacia*, Punaauia District, Tahiti, June 20 and July 16.

Tremella frondosa Fr. Syst. Myc. 2: 212. 1822. The fructifications of the Tahitian collection have thin foliaceous lobes and are yellowish brown when moist, drying dark brown. In some parts of the fructification large numbers of hymenial conidia are produced in chains on the hyphae. Basidia may be found in the same areas. The basidiospores are typically oval, somewhat flattened on one side, and measure 4.1–7.2 × 9.5–10.8 μ. These measurements are close to those given by Coker (1920).

Some authors doubt that *T. foliacea* and *T. frondosa* are distinct. Although I have not made a detailed study of these species, it has been my impression that *T. frondosa* is lighter brown, has hymenial conidia (which are lacking in *T. foliacea*), and, at least in the Tahitian collection, has spores that tend to be oval rather than subglobose.

Collected once on decorticate and corticate parts of a dead limb, Paea District, Tahiti, April 4.

SIROBASIDIACEAE

Tender gelatinous or soft gelatinous, white, reddish brown, or brown, pustulate to convolute and gyrate, or foliaceous; basidia borne in chains, 2–4-celled, the septa vertical to transverse; protosterigmata sporoid, ovate, subelliptic, or fusiform, becoming detached from the basidium and ger-

minating to form basidiospores, conidia, or germ tubes; basidiospores apiculate, germinating by repetition or by budding. The single genus *Sirobasidium* has the characteristics of the family.

Bandoni (1957) has shown that the ovate to fusiform structures formerly believed to be sessile basidiospores are actually sporoid protosterigmata ("epibasidia") and that these, after falling off the basidia, may give rise to the true basidiospores, which in *S. sanguineum* are subglobose. They are of similar shape in the Tahitian collections of *S. magnum*. It is probable that the relationship between the Sirobasidiaceae and Tulasnellaceae has been exaggerated by Bandoni. He states that catenulate basidia are occasionally found in members of the latter family. The evidence for this is inadequate. In my own studies of many species of this group, I have never observed as many as two basidia in a series. The Sirobasidiaceae appear more likely to be an offshoot from the Tremellaceae, the basidia of the two families being essentially alike.

Sirobasidium magnum Boed. Jard. Bot. Buit. III, 13: 266–268. 1934. (Fig. 18). Gelatinous, dull tan to somewhat reddish brown with bumpy irregular surface, or much contorted and with upright folds, smaller fructifications 1.5–7 mm. broad, larger ones up to 2.5 cm. broad and 1 cm. high; basidia subglobose to fusiform, in chains of 4–8, with clamp connections at their bases, 2-celled only or 2–4-celled with 2-celled forms predominating or with 2- and 4-celled basidia almost equally common, septa vertical to transverse, walls of empty basidia becoming tan, 6.8–12.2 × 11.7–29.7 μ; protosterigmata typically fusiform, deciduous, 4–8 × 10.4–28 μ; basidiospores globose to subglobose, distinctly apiculate, often appearing slightly broader than long, 6.5–9 × 6.8–9.5 μ, germinating by repetition.

On corticate and decorticate parts of dead limbs, including those of *Acacia* and *Eugenia jambolana*, Punaauia District, Tahiti, May 16–21, June 9.

The species was originally discovered in Borneo and Java and has also been found in India. Except for the general occurrence of the basidia in longer chains, it shows a close resemblance to *S. sanguineum* and might almost be considered a variety of that species. Lowy (1956) has separated the two species in his key mainly on the basis that *S. sanguineum* has predominantly 4-celled basidia while *S. magnum* has mostly 2-celled basidia. However, in a large and well-developed collection of the former from Maryland (Olive 1946), the majority of basidia were 2-celled. In my Tahitian collections of *S. magnum*, 2-celled and 4-celled basidia are occasionally almost equally common. It is clear, therefore, that this is not always a reliable character in the separation of species of *Sirobasidium*. *S. indicum* Ram. & Subr. and *S. brunneum* Lloyd are not mentioned in Lowy's article.

TULASNELLACEAE

Fructifications arachnoid, waxy, waxy-gelatinous, mucous-gelatinous, or firm-gelatinous, typically thin, resupinate; metabasidium budding out four inflated protosterigmata with septa at their bases; protosterigmata

producing the spore-forming spicules directly or at the ends of cylindric sporogenous filaments; basidiospores germinating by repetition or occasionally by budding out small conidia.

In a recent paper (1957b), in which I revised the family Tulasnellaceae to include *Gloeotulasnella* as a subgenus of *Tulasnella*, two new Tahitian species, *T. guttulata* and *T. pacifica*, were described. In view of this recent treatment, only keys to the subgenera and species are given here, and descriptions of the five species found in the Society Islands will be omitted from this paper.

KEY TO THE SUBGENERA

Fructifications arid-pruinose, waxy or firm- to soft-gelatinous; gloeocystidia lacking ..... *Tulasnella*

Fructifications gelatinous-waxy to mucous-gelatinous; gloeocystidia present ..... *Gloeotulasnella*

KEY TO THE SPECIES

TULASNELLA

1. Basidiospores slightly curved-cylindric ..... *T. caroliniana.*
1. Basidiospores subglobose to short cylindric, not curved 2
   2. Basidiospores subglobose to broadly ovate, fructifications typically lilaceous ..... *T. violea.*
   2. Basidiospores oblong to subcylindric, fructifications typically grayish white ..... *T. bifrons.*

GLOEOTULASNELLA

1. Gloeocystidia abundant, not exceeding 75 μ in length, frequently guttulate ..... *T. guttulata.*
1. Gloeocystidia sparse, often exceeding 75 μ (up to 160 μ) in length, not guttulate ..... *T. pacifica.*

CERATOBASIDIACEAE

Arid to waxy or hypochnoid; gloeocystidia (and possibly cystidia) present or absent; metabasidia subglobose, pyriform, or broadly clavate, 1-celled producing 4, sometimes 2, cornute protosterigmata or less often 4 awl-like to slender sterigmata; basidiospores germinating by repetition.

Metabourdotia tahitiensis Olive. Amer. Jour. Bot. 44: 429. 1957. (Fig. 2C)

Formerly, only the single genus *Ceratobasidium* was known. In the paper cited above, two new genera, *Metabourdotia* and *Heteromyces* were described. The description of *Metabourdotia* was based on material of a new species from Tahiti, the three collections of which were found growing primarily on old ascomycete stromata on dead limbs. The species is readily recognized by its gloeocystidia and its clavate basidia with cornute protosterigmata, basidia that greatly resemble those of *Ceratobasidium* but which develop septa that are cruciformly arranged apically and incomplete below. The fungus appears to be a connecting link between the section *Bourdotia* of *Sebacina* and the Ceratobasidiaceae. In view of the recent, fuller description of this fungus, no further treatment of it is given here. It is the only species of the family that was found in Tahiti.

Growing mostly on a black stromatic pyrenomycete on corticate dead limbs, including those of *Mangifera indica*, Punaauia District, Tahiti, June 20 (T358, type), June 26 (T367, cotype; T372).

In the paper in which *Metabourdotia* was described, I briefly discussed the possibility of an evolutionary line leading from Tremellaceae to Clavariaceae. Since the publication of this paper, two other references bearing upon this same subject have come to my attention. The recent investigations of Crawford (1954) describing *Tremellodendropsis* (Corner) Crawford as a new genus of Clavariaceae and of Reid (1956) describing the new genus *Pseudotremellodendron* of the Tremellaceae very strongly support the theory that at least a certain group of fungi now classified among the Clavariaceae have evolved in a direct line from *Tremellodendron*-like forms in the Tremellaceae. Crawford's subgenus *Transeptia* of *Tremellodendropsis* has stalked-clavate, cruciformly septate basidia very much like those of *Sebacina petiolata* and several other species of Tremellaceae. The importance of the transverse septum at the base of the enlarged portion of the basidium has undoubtedly been overemphasized by Crawford.

Reid's new genus *Pseudotremellodendron* relegates Crawford's subgenus *Transeptia* to synonymy with it, and Reid includes the group in the Tremellaceae where it obviously belongs. It is significant that the basidiospores germinate by repetition. Neither author makes it clear why these forms with complete cruciform septa in the basidia are excluded from *Tremellodrendron*. I fail to find in their descriptions any useful criteria that justify recognition of this separate treatment.

Crawford's genus *Tremellodendropsis*, in accordance with Reid's treatment would be left with a single species, *T. tuberosa* (Grev.) Crawford, with incomplete cruciform septa in the basidia. There is no evidence that the spores germinate by repetition, but the incomplete septa strongly indicate an intermediate position for this genus in the evolutionary line leading from Tremellaceae to Clavariaceae. In view of its partially septate basidia, I would be inclined to place the genus close to *Tremellodendron* in the Tremellaceae. It occupies a position in this evolutionary series similar to that of *Metabourdotia* in its series.

DACRYMYCETACEAE

Fructifications effused, pustulate, cerebriform, upright and lobed, or stipitate and pileate, waxy to tough gelatinous, hymenial conidia sometimes present, metabasidia clavate-cylindric, non-septate, producing two stout cylindric protosterigmata; basidiospores typically allantoid, usually becoming septate and budding out small conidia.

KEY TO THE GENERA

1. Fructifications pustulate at origin, anastomosing and becoming effused, waxy-gelatinous to soft-gelatinous ..... *Arrhytidia.*

1. Fructifications not effused, firmly gelatinous 2
   2. Pulvinate, cerebriform, or erect and lobed, not distinctly stipitate ... *Dacrymyces.*
   2. Erect, spathulate and stalked ..... *Dacryopinax.*

ARRHYTIDIA

Fructifications typically originating as pustules that coalesce to form flattened, effused masses with irregular surface, tough waxy-gelatinous, sometimes soft gelatinous; with or without hymenial conidia; cystidia present in one species; basidia typical; basidiospores becoming 1–3 (–4)-septate.

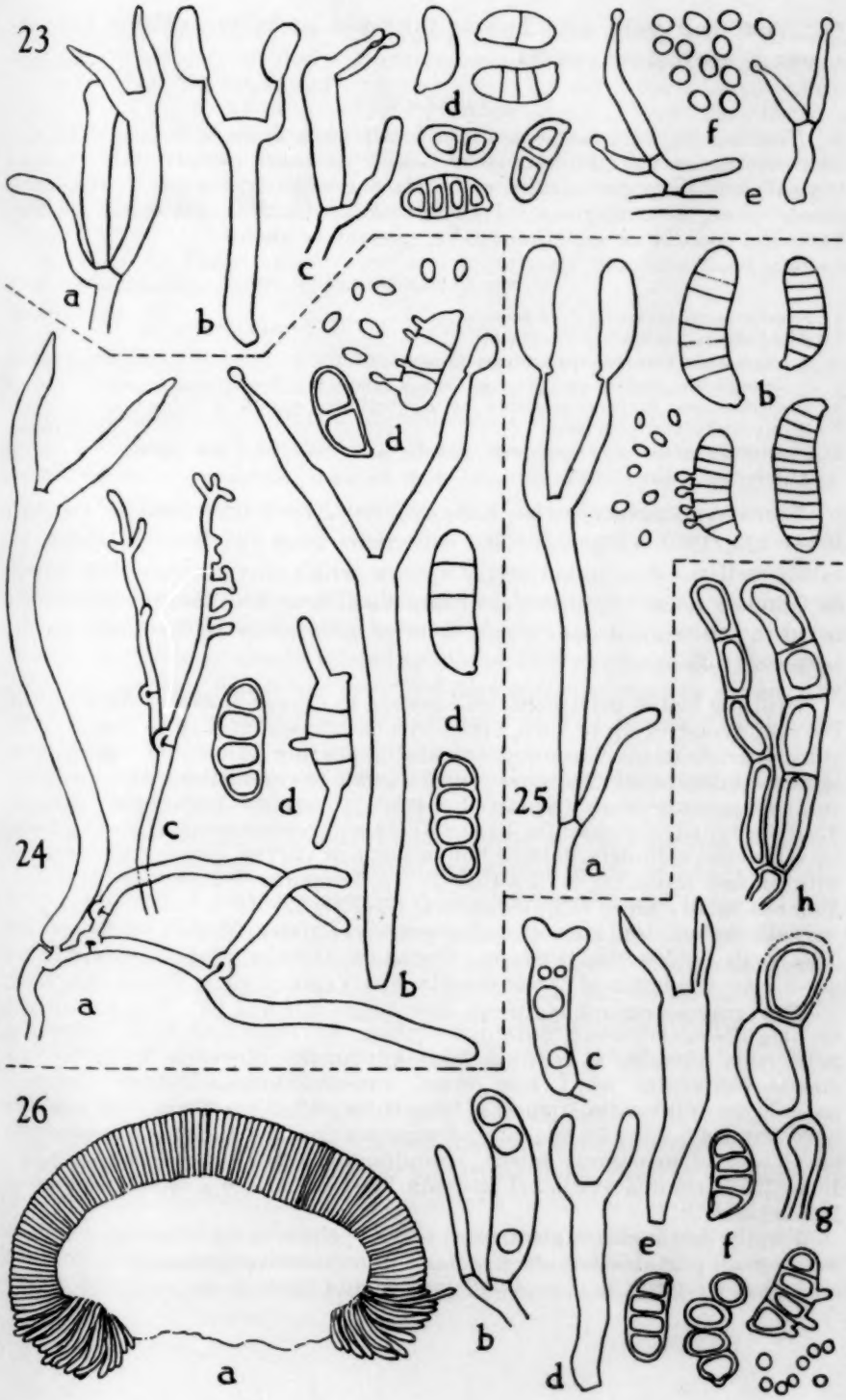
Arrhytidia lagerheimi (Pat.) comb. nov. (Fig. 2E and 23) *Ceracea lagerheimi* Pat. Bull. Soc. Myc. Fr. 9: 141. 1893. Fructifications orange-tan, fleshy-gelatinous to very soft gelatinous, with or without conspicuous, whitish to cream-colored, arid subiculum, resupinate and flattened, with uneven surface, larger fructifications forming by confluence of smaller ones, up to several centimeters in extent and 0.8 mm. thick, drying tan to brown with subiculum becoming more apparent. Hyphae without clamp connections, often with gelatinous-thickened walls; paraphyses lacking; hymenial conidia present in separate or mixed fructifications, produced on phialide-like structures, globose to broadly ovate, yellowish in mass, 2.3–3.3 × 2.3–4.5 μ; basidia typical, yellowish, 3.6–5.4 × 19–42 μ; basidiospores yellowish, apiculate, 4.1–6.3 × 10.8–16.2 μ, becoming 1–3-septate with gelatinized-thickened walls and septa; not budding out conidia in this material.

Collected twice on dead decorticate wood of *Hibiscus tiliaceus*, Punaauia District, Tahiti, May 21 and July 10.

I have examined type material of *Ceracea lagerheimi* Pat. from Ecuador and find it similar in most ways to the Tahitian material. It has tan, soft-gelatinous fructifications with felty, white subiculum and basidiospores whose walls and septa become very thick. Although these spores are predominantly 1-septate, some are 2–3-septate. They measure 5.4–7.5 × 12.6–18.9 μ, thus being less narrow than those of the Tahitian collections. Nevertheless, the two are so similar in other respects that I have decided not to consider the Tahitian material even of varietal rank.

Brasfield (1938) has suggested the possibility that this species may be synonymous with *A. involuta*. However, I believe that there are significant differences which warrant separation of the two as distinct species. Such features as the arid subiculum, soft texture, thick-walled basidiospores, and the hymenial conidia readily separate *A. lagerheimi* from *A. involuta*. The

FIGS. 23–26. Tremellales of Tahiti. FIG. 23. *Arrhytidia lagerheimi*. a–c, development of basidia and spores. d, basidiospores, some with gelatinous-thickened walls. e, phialide-like conidiophores. f, conidia. FIG. 24. *Dacrymyces paraphysatus*. a, probasidia and mature basidium. b, basidium producing spores. c, paraphysis. d, basidiospores, one producing germ tubes, another budding out conidia. FIG. 25. *Dacrymyces san-augustinii*. a, basidium producing spores. b, multiseptate basidiospores, one budding out conidia. FIG. 26. *Dacrymyces intermedius*. a, vertical section through fruiting body showing hymenium and peripheral layer of cortical hairs. b–e, stages in basidial development. f, basidiospores and conidia. g, h, cortical hairs. (All figures × 925 except fig. 26a, × 90)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fact that their walls soon become thickened probably explains why the spores do not bud out conidia.

DACRYMYCES

Fruiting bodies gelatinous, often firmly so, pulvinate, flattened-discoid, cerebriform, or upright and lobed, sessile or rarely substipitate; basidia typical; basidiospores usually cylindric and slightly curved to reniform; rarely ovoid, becoming septate and generally budding out small conidia; hymenial conidia, or sometimes oidia, present or absent.

KEY TO THE SPECIES

1. Basidiospores becoming 7–13-septate ..... *D. san-augustinii.*
1. Basidiospores becoming 3-septate 2
   2. Numerous branched paraphyses present ..... *D. paraphysata.*
   2. Paraphyses lacking 3
3. Fructifications flattened-pulvinate to cerebriform, mostly 1–13 mm. diam., without cortical hairs ..... *D. deliquescens.*
3. Fructifications discoid or pulvinate, minute, mostly under 0.5 mm. diam., with cortical hairs ..... *D. intermedius.*

Dacrymyces san-augustinii Kobayasi. Sci. Rep. Tokyo Bunrika Daigaku B. 4: 122. 1939. (Fig. 25). The collections from the Society Islands fit rather well the description of the species, which was discovered in Japan on frondose wood. The presence of occasional branched paraphyses was not noted in the original description. A brief description of the South Pacific collection follows.

Fruiting bodies gelatinous, dull orange to orange-brown or dark brown, 1–6 mm. broad, or up to 1 cm. broad by anastomosis, and up to 2 mm. thick, older fructifications flattening out and appearing thinner or occasionally almost applanate, surface somewhat irregular to cerebriform. Hyphae without clamp connections; scattered, narrow, branched paraphyses present, 0.8–1.6 μ broad; metabasidia 3.7–5 × 37–54 μ; protosterigmata 18–40 μ long; basidiospores cylindric, flattened on one side or curved, occasionally arcuate, with bilobed apiculus, 4–7.2 × 15.3–25.7 μ, becoming 7–13-septate and budding out small oval to elliptic conidia, 1.2–1.8 × 2.3–3.6 μ.

Collected on dead stem of *Coffea arabica*, Raiatea, May 7; on decorticate dead limb of *Hibiscus tiliaceus*, Punaauia District, Tahiti, May 21; on decorticate dead limb of *Citrus limetta*, Faa Tautia Valley, Tahiti, August 9.

Dacrymyces paraphysatus sp. nov. (Figs. 2D and 24). Fructificationes cartilaginoso-gelatinosae, aurantiaco-luteae, ad fusco-brunneum vergentes, primordiis pustulis, in laminas latas applanatas superficie irregulari vel massas convolutas ad 1 mm. crass. anastomosantes. Hyphae nodosae; paraphyses lutescentes, ramosae, frequentes, 0.9–2.7 μ diam.; metabasidia lutescentia, 4.5–7.2 × 38–86 μ protosterigmata dua 18–51 μ long. producentia; basidiosporae in cumulo luteae, cylindraceae, sero 1–3-septatae, 5.4–7.2 × 13.5–22.5 μ, conidia ovalia vel elongata 1.4–2.4 × 2.7–4.6 μ modo gemmarum gignentia.

Firmly cartilaginous-gelatinous, orange-yellow to dark brown, originating as small pustules that often coalesce into extensive applanate layers with somewhat irregular to convoluted surface and up to 6 cm. long, 0.3–1 mm.

thick, drying to distinct reddish brown to blackish brown horny patches. Hyphae yellowish, provided with clamp connections; paraphyses abundant, typically much branched and irregular above, 0.9–2.7 μ diam.; metabasidia yellowish, 4.5–7.2 × 38–86 μ; protosterigmata 18–51 μ long; basidiospores yellow in mass, cylindric and flattened on one side or slightly curved, distinctly apiculate, 5.4–7.2 × 13.5–22.5 μ, the majority becoming 3-septate, with the walls and septa often becoming thickened, frequently budding out small oval to elongate conidia, 1.4–2.4 × 2.7–4.6 μ, or germinating by means of germ tubes.

Common in Tahiti on corticate and decorticate frondose wood and on dead bamboo stem (T122, type; T53, cotype).

The species illustrates well the difficulty in separating certain genera in this group on the basis of whether the fructifications are effuse or discrete. In some collections the fructifications remain fairly distinct in spite of a tendency to coalesce. In others, the coalescence is so extensive as to produce broad, thin, applanate layers that have free margins but which often adhere to the substrate throughout most of their breadth. The latter type of fructification for the most part resembles that considered characteristic of *Arrhytidia*. The species is probably intermediate between *Dacrymyces* and *Arrhytidia*.

The basidiospores whose walls become thickened apparently do not bud out conidia; only the thin-walled spores seem capable of generating them.

Perhaps the most closely related species of *Dacrymyces* is *D. applanatus* Kobayasi (1939b), which was described on coniferous wood in Japan. The latter species has narrower basidia, generally shorter spores, and there is no mention of paraphyses in the description.

Dacrymyces deliquescens (Mérat) Duby. Bot. Gall. 729. 1829. *Dacrymyces ellisii* Coker. Jour. Elisha Mitchell Soc. 35: 167. 1920. For some time I have suspected that *D. deliquescens* and *D. ellisii* are the same species. After having made numerous collections in the United Stats as well as in the Society Islands, I am now convinced of their synonymy. Coker (1920) did not clearly explain why he considered the two as distinct species. Brasfield separates the two mainly on the basis of size of the fructifications, which he finds to be deeply rooted only in *D. ellisii*, and on the basis of the hyphae, which he generally finds to be roughened in *D. ellisii* but rarely so in *D. deliquescens*. He mentions that walls and septa of the spores of the latter species become thick and gelatinous.

The collections from the South Pacific show all kinds of intergradations with regard to the above-mentioned characters. Even different fructifications of the same collection show the variations emphasized by Brasfield in distinguishing the two species. With regard to the basidiospores, it was interesting to note that when conditions favored the budding out of conidia, the spore walls and septa generally remained thin, otherwise they became gelatinous-thickened and the spores failed to produce conidia. The rough-

walled condition of the hyphae of the fructifications is caused by the gelatinization of the outer hyphal walls, a condition which varies from one fructification to another.

Catenulate oidia have long been known to occur in *D. deliquescens,* but have not been reported in *D. ellisii.* I recently examined the type collection of *D. ellisii* (No. 3861, UNC) and found that it also has catenulate oidia. These measure 3.4–6 × 7.7–21.6 μ and thus compare very favorably in size with those of *D. deliquescens.* The fructifications have a range of 0.6–6.2 mm. in diameter, and the basidiospores measure 4.9–6.3 × 11.7–17.1 μ, which is essentially the same as the spore dimensions recorded for *D. deliquescens.*

The fructifications of the South Pacific collections are quite variable in size and color, ranging from orange-yellow to brownish orange and 0.5–8 mm. in diameter. They are sessile or substipitate, the larger ones becoming folded or cerebriform, sometimes with whitish radicating bases, particularly when growing on corticate limbs. A few cortical hairs with gelatinous-thickened walls were found in one collection (T195). No oidia were observed, but in one collection (T206), hymenial conidia produced on reduced phialides in bushy clusters were found, these clusters sometimes being attached to basidial hyphae. Hymenial conidia apparently have not been previously reported in this species. The basidiospores typically become 3-septate (rarely 4- or 5-septate) and measure 4.5–7.5 × 11.7–17.4 μ.

Very common on various kinds of corticate and decorticate frondose wood, Tahiti, Moorea, Raiatea, Bora-Bora.

Dacrymyces intermedius sp. nov. (Fig. 26). Fructificationes gelatinosae, brunneo-aurantiacae, minutae, primo hemisphericae vel applanato-discoideae, sessiles, 0.15–1 mm. diam., in massas ad 2 mm. diam., 0.4 mm. crassit. coalescentes. Hyphae enodosae; capilli corticales crasse tunicati circum marginem orientes; metabasidia lutea, 5–7.2 × 21.6–41.4 μ, protosterigmata dua 11.7–20 μ long. producentia; basidiosporae subluteae, curvulo-cylindraceae, sero 3-septatae, 4.2–7.4 × 10.7–16.7 μ, conidia parva globosa vel subglobosa 1.4–2.7 μ diam. modo gemmarum producentes.

Gelatinous, brownish orange, minute, originating as hemisphaerical to flattened-discoid, sessile bodies, 0.15–1 mm. diam., coalescing to form masses up to 2 mm. long and 0.4 mm. thick, drying to minute, orange-brown, flattened bodies. Hyphae without clamp connections; cortical hairs with gelatinous-thickened walls arising around the margin just underneath the fructification; paraphyses absent; metabasidia yellowish, with large oil droplets, 5–7.2 × 21.6–41.4 μ; protosterigmata 11.7–20 μ in length; basidiospores yellowish, slightly curved-cylindric, 4.2–7.4 × 10.7–16.7 μ, becoming 3-celled and budding out small globose or subglobose conidia 1.4–2.7 μ in diameter or with walls and septa becoming conspicuously gelatinous-thickened, the cells often separating in the older spores.

Collected once on dead decorticate limb of *Hibiscus tiliaceus,* Punaauia District, Tahiti, July 13 (T430, type).

It is a rather arbitrary decision to place this species in the genus *Dacrymyces.* It could almost as well have been placed in *Guepiniopsis.* I

consider it intermediate between the two genera. *Guepiniopsis* is characterized by discoid to cupulate, usually stalked, fructifications with thick-walled cortical hairs. Also, it has been my impression that the fructifications of *Guepiniopsis* do not coalesce, or, if they occasionally adhere at their margins, they retain their individual identity. The fruiting bodies of *Dacrymyces* are sometimes discoid also, but they are typically non-stipitate and coalesce readily when they grow crowded together, as is characteristic of the present species. Although cortical hairs are considered characteristic of *Guepiniopsis* and not of *Dacrymyces*, Kennedy (1956) has found them to be quite common in *D. palmatus*. As noted previously in this paper, a few scattered cortical hairs were found in a Tahitian collection of *D. deliquescens*. *Guepiniopsis minuta* Olive (1954) with its small, nearly sessile to distinctly stipitate fruiting bodies may be the species most closely related to *D. intermedius* in that genus.

Dacryopinax spathularia (Schw.) Martin. Lloydia 11: 116. 1948. The species is readily recognized by its spathulate, orange fruiting bodies with somewhat tomentose stalks. The natives call it *tutae tupapau* or "ghost's dung." Although only one collection was made, the species was observed several times in the area.

On dead decorticate limb, Taravao District, Tahiti, March 18.

The writer is grateful to Dr. D. P. Rogers for preparation of the Latin descriptions and for the loan of herbarium material from the New York Botanical Garden. I am also indebted to Dr. I. M. Lamb for the loan of a number of specimens from the Farlow Herbarium. Type material of the new species has been deposited in the mycological collections of the New York Botanical Garden and of the United States Department of Agriculture at Beltsville, Maryland.

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THE COMPARATIVE ANATOMY AND TAXONOMY OF HETEROPYXIS[1]

WILLIAM L. STERN AND GEORGE K. BRIZICKY

The genus *Heteropyxis*,[2] established by Harvey in 1863, has been variously placed with families of one systematic position or another. At present no wholly satisfactory evidence has been forthcoming from conventional taxonomic study to establish with certainty the affinities of *Heteropyxis*. Comparative anatomy of the vegetative organs has proven helpful in assisting the taxonomist to ascertain the natural relationships of other doubtfully classified taxa. As the works of I. W. Bailey and his students have amply demonstrated, comparative anatomical studies are based on criteria remarkably free from preconceptions regarding relationships among plants. Therefore, suggestions supported by evidence from comparative anatomy should be especially valuable to the systematist. In the present study, the observations of the taxonomist and comparative anatomist have independently led to the same conclusions regarding the affinities of the taxon in question.

Harvey (1863), in his *Thesaurus capensis*, placed *Heteropyxis natalensis* (the type species) in Heteropyxideae, a specially erected appendix to Lythrarieae. He remarked that it was possibly related to Myrsineae, Lythrarieae or Rhamneae. Myrsineous relationship was dismissed in that ". . . in *Heteropyxis* the ovary is never unilocular, nor is the placentation 'free-central'." Also, affinity with Rhamneae was deprecated because *Heteropyxis* differs very much in the nervation of the leaves, the absence of stipules, in the structure of the inflorescence, in the possession of glandular dots, in the aestivation of the calyx and ". . . more especially in the polyspermatous placentae." Harvey follows, therefore, the suggestion of Hooker and Thompson (in corresp.?) and appends *Heteropyxis* to Lythrarieae stating that "The time has not come, therefore, for associating *Heteropyxis* with *Lythrarieae*, although we may admit an affinity, per-

[1] The authors would like to express their gratitude to Mr. Archie F. Wilson of Summit, New Jersey, for suggesting this problem and for supplying research material. Also for their kindness in offering specimens the authors would like to thank the Chief Forest Products Officer and the Chief of the Division of Botany in Pretoria, South Africa, and the Director of the Royal Botanic Gardens at Kew in England. Special thanks are due to Professors Vernon I. Cheadle and Katherine Esau of the Department of Botany, University of California at Davis, for their examination of, and helpful suggestions regarding, the phloem problem in these plants.

[2] *Heteropyxis* Harvey (1863) is a *nomen conservandum propositum* versus *Heteropyxis* Griffith (1854; Bombacaceae). The latter is a synonym of *Boschia* Korthals (1844); (Bullock, 1957).

haps sufficient to authorize our placing it in an appendix to that order." Remarkably, Harvey named the genus after a supposed character of the fruit which he never saw and did not describe, "The name . . . was given to it on the supposition that it might prove to be an anomalous genus of *Myrsineae*, and was intended to allude to the character of the ovary which separates it from other genera of that Order."

Bentham and Hooker (1867) included *Heteropyxis* in Lythrarieae, but as an anomalous genus. Of importance here is the description of the fruit which was not included in the definition of the genus by Harvey. Oliver, in 1895, described a second species, *Heteropyxis canescens*, from the Transvaal. Two important features of the ovary, its turbinate shape and depressed apex, are noted by this author. Without any remarks, Oliver places *Heteropyxis* under Lythraceae.

Heteropyxis transvaalensis was added to the genus in 1896 by Schinz. However, the author soon realized that his new species was conspecific with Oliver's *H. canescens* (based on the same specimen!). Schinz pointed out that *Heteropyxis* shows certain similarities to Myrtaceae in that secretory cavities and internal phloem occur in each group. He tentatively placed the genus in Myrtaceae, but noted that it should have a special place here as it has a superior ovary and does not have bicollateral vascular bundles in the leaves.

That *Heteropyxis* should definitely be excluded from Lythraceae was asserted by Engler in 1897. Although not definitely referring *Heteropyxis* to any family, he remarked that the glands in *Heteropyxis* are lysigenous as in Rutaceae, but that the flowers of these two groups have little in common. Furthermore, if *Heteropyxis* were to be placed in Rutaceae, it would have to be in a separate subfamily. Engler was the first to mention (and presumably to notice) the occasional presence of 2 or 3 stamens opposite the sepals which accompany the 5 opposite the petals. In line with Engler's ideas, Koehne, in his monographic study of Lythraceae (1903), lists *Heteropyxis* among *"genera excludenda."*

Hallier (1903), basing his remarks on the floral structure and secretory cavities in both taxa, states that *Heteropyxis* belongs to Myrtaceae. Indeed, he suggests that it is closely related to the genus *Metrosideros* of the subtribe Metrosiderinae (tribe Leptospermeae). Thonner (1908) agreed with Hallier in that *Heteropyxis* should be in Myrtaceae, and assigned it to the tribe Leptospermeae close to *Psiloxylon*.

Engler again considered *Heteropyxis* in 1915 describing it as an arborescent genus sometimes thought rutaceous because of the lysigenous glands in the leaves. He remarked, however, that it resembles the Myrtiflorae in its floral characters. Nevertheless, in his *Pflanzenwelt Afrikas*, *Heteropyxis* is placed in the *Anhang* to Rutaceae. Of particular note here is that Engler recommends the erection of a separate family, Heteropyxidaceae, to con-

tain *Heteropyxis*. This family, he states, should follow Lythraceae in the Myrtiflorae. In the 1919 edition of his *Syllabus*, Engler actually defined the family Heteropyxidaceae.

Hutchinson (1946) regarded Heteropyxidaceae as a link between Rhamnaceae and Myrsinaceae. In his 1926 work, he placed the Heteropyxidaceae in Rhamnales. Here Hutchinson credits *Heteropyxis* with only 5 oppositipetalous stamens. Apparently following Hutchinson, Phillips (1951) placed the Heteropyxidaceae in Rhamnales. Gundersen (1950) included Heteropyxidaceae in the order Myrtales after Lythraceae. Again here, only 5 oppositipetalous stamens are recorded. Because secretory cavities are virtually absent in Lythraceae, Metcalfe and Chalk (1950) stated that *Heteropyxis* ought probably to be excluded from this family.

In his studies on the morphology of pollen, Erdtman (1952) mentioned that "Pollen grains of the same type as those in Heteropyxidaceae occur in Myrtaceae. The grains in Crypteroniaceae, Lythraceae, Myrsinaceae, Rhamnaceae, and Rutaceae are more or less different." It is of further interest to note that "*Heteropyxis* . . . and *Psiloxylon* have typically myrtaceous pollen grains."

Recently, Suessenguth (1953), in his monograph of Rhamnaceae, remarked that the Heteropyxidaceae, which Hutchinson included in the Rhamnales, indeed have a hypanthium and stamens opposite the petals, but each locule of the ovary contains numerous ovules on a thick axial placenta. Also, the leaves are pellucid dotted in Heteropyxidaceae. He concluded that a close relationship between Rhamnaceae and Heteropyxidaceae cannot be substantiated.

The genus *Heteropyxis* has been bandied about among several families, namely: Lythraceae, Rhamnaceae, Rutaceae and Myrtaceae. It has been treated as a genus of a family and as a separate family in its own right. The original description did not include a statement regarding the structure of the fruit, and even now the exact number and position of the stamens is in doubt. Some workers report bicollateral vascular bundles in the leaves, and others specifically state that this is not the case. It is hoped that the following descriptions and discussions will clear up these discrepancies.

Materials and methods. Results of this investigation are based on anatomical evidence derived from wood, flowers and fruits, stems and leaves. Wood of *Heteropyxis natalensis* was obtained from two sources: A cross section of a tree trunk (9–12cm. diameter) was donated by the Chief Forest Products Officer, Forest Products Institute, Pretoria, Union of South Africa. A second specimen was obtained through Mr. Archie F. Wilson of Summit, New Jersey from Mr. W. C. E. van Wyk who collected it near Pretoria. Both samples are housed in the Samuel James Record Memorial Collection of the Yale School of Forestry and bear the collection numbers Y-50326 and Y-50136 respectively.

Young twigs of *Heteropyxis natalensis* employed in the description of the node, internal phloem, and leaves were obtained, preserved in formalin-acetic acid-alcohol, from the Chief, Division of Botany, Department of Agriculture, Pretoria. These specimens were collected from a young tree grown at the Prinshof Experimental Station in Pretoria. Descriptions of the external morphology are based mainly on herbarium specimens acquired from Kew and the Chief of the Division of Botany in Pretoria. Herbarium specimens examined are as follows: *H. natalensis:* Acocks 12724 from Pretoria; Smuts and Pole-Evans 842, Bolus 11884, Hutchinson 1907, Rudatis 267 from Kew. *H. canescens: Miller* S/250 from Pretoria and Miller S/219 from Kew. Duplicates of the Acocks specimen and Miller S/250 are housed in the herbarium of the Record Collection. It should also be noted that petiole sections were taken from Acocks 12724 (*H. natalensis*) and Miller S/250 (*H. canescens*).

Wood was sectioned according to conventional methods: blocks were boiled in water and cut on a sliding microtome. A Heidenhain haematoxylon-iron alum staining procedure was followed by safranin. Canada balsam was employed as a mounting medium. Petioles were embedded in paraffin, celloidin or were sectioned without embedding. Young stems for internal phloem and nodal analysis were cut after embedding in celloidin, or were cut without embedding. Elder pith was used to support unembedded material in the microtome. For the demonstration of starch, an iodine-potassium iodide solution was used.

Terms used in describing the wood follow the recommendations of the Committee on Nomenclature of the International Association of Wood Anatomists (1957). Vascular ray designations are those of Kribs (1935). Because of the limited material, no attempt was made to apply detailed statistical procedures to the measurements of cell size. Means and extremes given in the anatomical section are based on 100 measurements of pore diameters, vessel element and fiber lengths. Vessel elements were measured from tip to tip. For the sake of comparison, the means presented for dicotyledonous woods in Appendix I, Tables 1, 2 and 4 of Metcalfe and Chalk (1950) are included in the section on wood anatomy.

In sectioning the petioles, the suggestions of Metcalfe and Chalk were followed; that is, sections were taken from the most distal portion of the petiole. Employing this method consistently enables one to compare analogous portions of petioles.

Photographs were taken using a bench-type Bausch and Lomb photomicrographic apparatus with their DDE microscope. Green (B No. 58) and red (A No. 25) Wratten filters were employed in some of the photography.

Description of the genus. *Heteropyxis* is composed of two species growing in southeastern Africa: *H. natalensis* Harvey and *H. canescens* Oliver. These small evergreen trees or shrubs are characterized by the pres-

ence of subepidermal secretory structures in leaves (fig. 2), flowers and young stems. Leaves are alternate, simple, entire or finely repand and lanceolate to oblanceolate-oblong (fig. 1c, e). Flowers (fig. 1a, b) are small, fragrant, whitish, actinormorphic, bisexual and are borne on short pedicels in terminal and axillary panicles.[3] Floral parts are perigynous. The 5 sepals are imbricated in aestivation. Inserted at the rim of a cup-shaped hypanthium, the 5 petals are 2 or 3 times the length of the sepals, and are subcircular, oval or obovate, slightly concave, inconspicuously clawed, and

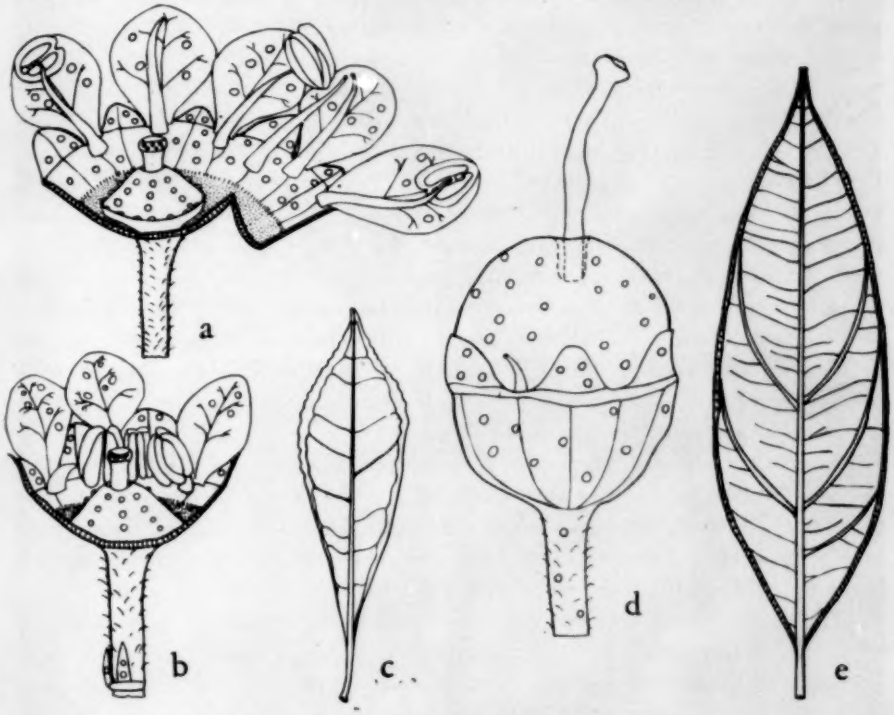


FIG. 1. a–d. *Heteropyxis natalensis.* a. Fully expanded flower showing the position of the stamens and pistil, and the gland-dotted floral parts, × 15. b. A partially expanded flower illustrating the cupulate nature of the calyx and the position and form of bracteoles, × 15. c. Leaf with repand margins, about × 0.8. d. Capsule showing the persistent hypanthium and the depression in the apex of the ovary represented by a dashed line, × 15. e. *Heteropyxis canescens.* Leaf with entire margins showing relative size compared with that of *H. natalensis,* about × 0.8.

imbricated in the bud. Stamens usually number 5, are opposite the petals, inserted with them and more or less as long as the latter. Sometimes 1–3 (5?) stamens opposite the sepals and inserted within the hypanthium also

[3] The inflorescence, at least in *H. natalensis,* appears to be thyrsoid and not a typical paniele.

occur. It is probable that the basic number of stamens in *Heteropyxis* is 10. Filaments are subulate and usually longer than the anthers. The latter are dorsifixed and versatile, 2-celled, dehiscing introrsely by means of longitudinal splits. The ovary is superior, turbinate with a depressed apex, usually 2-carpellate (very rarely 3) and 2-locular (very rarely 3). The fleshy axile placenta bears numerous ovules. The single, short, cylindrical style is situated in the apical depression of the ovary. The stigma is capitate. Fruits (fig. 1d) are small, usually bilocular capsules which dehisce loculicidally. The persistent hypanthium partly or almost entirely envelopes the fruit at maturity. Seeds are few, brown, lanceolate-oblong, slightly curved, acute at both extremities and triangular in transverse section. The embryo is straight, cotyledons are oblong, plano-convex and slightly longer than the stout radicle. There is no endosperm.

The two species may be distinguished as follows: *Heteropyxis natalensis:* Leaves oblanceolate, smaller (7–9cm. long), chartaceous, glabrous on the lower surface, margins finely repand not revolute (fig. 1c), lateral veins inconspicuous on both surfaces; capsule (fig. 1d) shortly but conspicuously pedicellate, ovate to oval in outline and included in the hypanthium for ⅓ to ½ the length. *H. canescens:* Leaves lanceolate-oblong to oblanceolate or elliptical, larger (11–13cm. long), subcoriaceous, puberulent on the lower surface, margins entire strongly revolute (fig. 1e), lateral veins prominent on the lower surface; capsule globose, subsessile, and almost entirely included in the hypanthium.

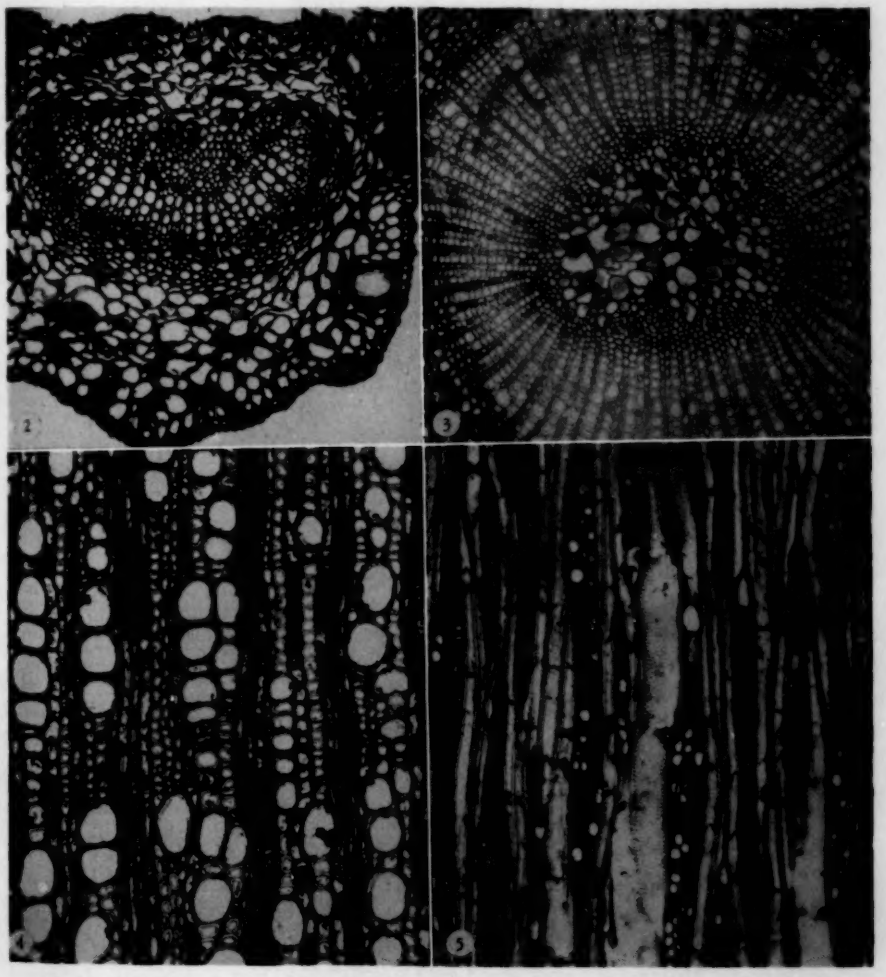
Anatomy. Growth layers in *Heteropyxis* are poorly defined, variable in radial width, and often fuse with each other. Their demarcation is due to tangential layers of somewhat thicker walled, flattened fibers. Since pores are fairly evenly distributed and are not larger in one part of the growth layer than in another, the wood is diffuse porous (fig. 4).

The imperforate tracheary elements are fiber-tracheids (sensu Bailey 1936) which have small bordered pits with elongate, crossed inner apertures. The latter extend beyond the circular borders of the pits. Pits are most abundant on the tangential walls but also occur on radial walls. Besides connecting adjacent fiber-tracheids, pit-pairs are present between the latter cells and those of the vascular rays.

Some of the fiber-tracheids in Y-50326 show gelatinous inner walls. These cells are conspicuous, as the inner walls stain darker and are more opaque than the outer walls. Although the presence of gelatinous fibers may be of diagnostic importance in certain taxa, it is doubtful that this is the case here, for it was noted that the above-mentioned specimen exhibited eccentric growth. It is well known that tension wood, which is frequently associated with such growth, is characterized by gelatinous fibrous elements.

Fiber-tracheids range in length from 323 μ to 1275 μ in Y-50326, and from 255 μ to 1122 μ in Y-50136. The means for these two groups of measure-

ments, respectively, are 826 μ and 758 μ. According to the measurements in Appendix I of Metcalfe and Chalk (1950), based on 534 species of dicotyledonous woods, these averages fall in the "short" range for fibrous elements. It is interesting to note that the arithmetic mean fiber length for the 534 woods is 1317.5 μ, well above the figures for *Heteropyxis*.



FIGS. 2–5. *Heteropyxis natalensis*. FIG. 2. Transverse section of petiole illustrating the arcuate nature of the vascular strand, the appearance of the adaxial phloem, formation of secondary xylem, and a subepidermal secretory cavity, ×95. FIG. 3. Transverse section of a young stem showing the "nests" of internal phloem on the periphery of the pith, ×100. FIG. 4. Transverse section of the wood demonstrating pores in solitary and radial multiple arrangements, lack of axial xylem parenchyma, and the dark deposits in the vascular ray cells and other elements, ×110. FIG. 5. Tangential section of the wood exhibiting the heterogeneous ray tissue, the pseudo-septations in the fiber-tracheids caused by the dark deposits, and the oblique vessel element end walls, ×110.

As viewed in macerations, the vessel elements present a varied appearance. In some, long ligules are evident; others are characterized by a lack of these appendages. Some elements are relatively long and narrow, others are short and broad, and still others are short and narrow. However, as the figures below indicate, this variation occurs within rather restricted limits when compared with vessel elements from a large range of dicotyledonous species.

Lengths of vessel elements range between 289 μ and 850 μ in Y-50326, and 289 μ and 816 μ in Y-50136. Averages are 572 μ and 547 μ respectively. According to figures based on 600 species of dicotyledons noted by Metcalfe and Chalk, the averages for vessel element lengths in *Heteropyxis* fall into the "medium" class.

Vessel walls are 3 μ to 4 μ in thickness. Pores display no obvious angularity and are mostly round or oval (fig. 4). They vary from 31 μ to 73 μ in tangential diameter for Y-50326 with an average of 48 μ, and from 22 μ to 62 μ with an average of 43 μ in Y-50136. The distribution of vessel diameters (pores) in Metcalfe and Chalk is based on 1500 species. Accordingly, vessel diameters in *Heteropyxis* fall into their "small" category (over 40 per cent of the species tabulated by Metcalfe and Chalk fall into this category). Pores (fig. 4) are mostly solitary (52 and 60 per cent) with a substantial percentage of radial multiples (34 and 43 per cent). Clusters form but a small part of the total distribution (3 and 6 per cent).

Perforation plates, even in the narrowest vessel elements, are simple. Intervascular pitting is alternate; pits are oval to round with elliptical, included apertures. Pits are abundant on vessel walls, but not so compressed as to form angular outlines. Pitting between vessels and rays is predominantly alternate. Occasionally vestiges of scalariform and transitional vessel —ray pitting are seen. All vessels which contact ray cells communicate with them through pits. The angle of vessel element end walls (fig. 5) varies from 25° to 70° but is most commonly 45°.

Axial xylem parenchyma is apparently lacking (fig. 4, 5). None could be detected in the material available for study.

Vascular rays correspond to Kribs (1935) Heterogeneous Type IIA (fig. 5). That is, the ray tissue comprises uniseriate rays made up solely of vertically elongated cells, and multiseriate rays with uniseriate "wings" composed of only vertically elongated cells. Multiseriate rays are from 2 to 5 cells wide. Uniseriate rays are 1 to 11 cells high, but are mostly between 3 and 5 cells in height. Multiseriate rays vary from 9 to 43 cells in height, but are most commonly from 15 to 20 cells high. In a few cases, disjunctive ray cells (Record 1934) were observed.

The lumina of the cells in *Heteropyxis* wood contain various types of deposits. In both specimens, starch occurs as globular granules in ray cells and fiber-tracheids. In specimen Y-50326, where an entire cross section of

the stem was on hand, starch was detected only in the inner portions of the wood. In specimen Y-50136, part of a cross section, starch was present throughout the wood.

Rhomboidal crystals were only observed in specimen Y-50136. These deposits were best observed in macerated material and were present in ray cells—one crystal to each cell.

All cells of the wood contain an amorphous deposit (fig. 4, 5) in greater or lesser degree—vessels contain the least; ray cells the most. Indeed the presence of this deposit in ray cells often conceals such details as the presence and form of crystals. In fibrous elements, the deposit may take the form of septa (fig. 5), and careful examination is needed to demonstrate that these agglutinations are not true septa (cell walls). In unstained preparations, the substance in question is dark amber in color and translucent. On staining, as previously outlined, this deposit darkens to a wine red color and becomes practically opaque.

There is a great probability that petioles of both species of *Heteropyxis* possess adaxial, arcuate, bicollateral vascular bundles surrounded by a sheath of sclerenchymatous elements which become more abundant in older petioles (fig. 2). Fibers on the adaxial side appear to have a phloic origin. Besides the primary xylem, abundant secondary xylem is formed by a vascular cambium. Secretory cavities are present in the subepidermal layers.

Intraxylary phloem (phloem internal to the primary xylem) is present in the stem seemingly in "nests" (as seen on the transverse section) next to the pith (fig. 3). The sieve tube members are narrow and contain slime. Companion cells seem to be identifiable as well.

Discussion. That there are certain morphological similarities between *Heteropyxis* and Lythraceae, Myrtaceae, Rhamnaceae and Rutaceae, has been pointed out previously by several botanists. This is confirmed in the present study of the comparative anatomy and taxonomy. There is little doubt that certain structures and structural arrangements have developed in a parallel manner in diverse groups of plants. Therefore, to infer relationship between taxa, the structural modifications of which have been incompletely treated, is indeed likely to lead to spurious conclusions. Another problem in this respect lies in the difficulties encountered in comparing a single, small genus, as *Heteropyxis*, with a large family of diverse structure. It is sometimes possible to select from the various members of large and heterogeneous families all, or almost all, the features to be found in a small genus under study. The fallacy of assumptions based on such work is apparent. Therefore, caution must also be exercised here to choose from large taxa, only salient features for comparison with small, homogeneous taxa. The totality of available evidence must be considered and interpreted carefully in order to select sound bases for inferring relationships.

In the opinion of the authors, *Heteropyxis* shows definite myrtalean

affinities and may even be placed directly into Myrtaceae. *Heteropyxis* is apparently not closely related to either Rhamnaceae or Rutaceae. Suessenguth, in his recent (1953) monograph on Rhamnaceae, asserts that the numerous ovules on a thick axile placenta and the pellucid-dotted leaves of *Heteropyxis* preclude close relationship between this family and Rhamnaceae, notwithstanding Hutchinson's (1926) treatment. Furthermore, Rhamnaceae are mostly stipulate, the flowers possess a disk, calyx lobes are valvate and seeds contain endosperm. A peculiar feature of Rhamnaceae is the strongly concave petals the claws of which seemingly clasp the filaments of the stamens. Also, *Heteropyxis* exhibits 1–3 supernumerary stamens opposite the calyx lobes, a condition which does not occur in Rhamnaceae. There is no record of the occurrence of either bicollateral vascular bundles in the petiole nor of internal phloem in Rhamnaceae. Rhamnaceae have trilacunar nodes (Sinnott 1914); *Heteropyxis* has unilacunar nodes. The wood of Rhamnaceae is not unlike that of *Heteropyxis;* however, the diversity of structure is far greater in Rhamnaceae (58 genera; Suessenguth 1953) than in *Heteropyxis*. A notable divergence is the presence of fibers with exclusively simple pits in Rhamnaceae.

With such a large and heterogeneous family as Rutaceae (145 genera; Engler 1931) it is more difficult easily to discount relationship with *Heteropyxis*. There is great variation in morphology throughout the tribes (11 according to Engler, 1931) of Rutaceae, however, there are a few consistent characters upon which the family is based, among which are: The intrastaminal disk, the usually few seeded (1–2) locules of the ovary, the secretory cavities, the incompletely or weakly united carpels in most Rutaceae (in only 3 tribes, Spathelieae, Toddalieae and Aurantieae, are the carpels entirely united; Engler, 1931), the trilacunar nodes (Sinnott 1914) and the petiole which usually exhibits a closed vascular cylinder. On these bases, we find that *Heteropyxis* and Rutaceae are only alike in the common possession of secretory cavities. Furthermore, Rutaceae do not have bicollateral vascular bundles in the petioles (except in *Orixa;* Metcalfe and Chalk, 1950) nor do they possess internal phloem.

Heteropyxis, in common with several myrtalean families, including Lythraceae and Myrtaceae, possesses bicollateral vascular bundles in the petiole and internal phloem. The petiolar bundle is arc shaped in *Heteropyxis,* Lythraceae and Myrtaceae, and a sclerenchymatous sheath is associated with this bundle in *Heteropyxis* and Myrtaceae. Lythraceae differs, however, from *Heteropyxis* as follows: Sepals are valvate, secretory cavities are absent (except in *Cuphea anagalloides;* Metcalfe and Chalk 1950), stamens of the outer whorl are alternate with the petals, floral parts are variously 4, 6 or 8 (rarely 5) and the septate xylem fibers exhibit simple pits. Reference to Erdtman (1952) shows that the morphology of the pollen is different in these two taxa.

Typical Myrtaceae (subfamily Myrtoideae) differ somewhat from *Heteropyxis:* Leaves are usually opposite, floral parts are mostly epigynous, stamens are usually numerous and axial xylem parenchyma is present. However, the totality of evidence from many sources indicates beyond reasonable doubt that *Heteropyxis* possesses evident myrtaceous affinities, e.g., the statements of Erdtman (1952) indicate that the pollen of *Heteropyxis* has morphological counterparts among the members of Myrtaceae, the common occurrence in each taxon of unilacunar nodes, arcuate, bicollateral petiolar vascular bundles, internal phloem, secretory cavities in leaves, flowers and young stems, vessels which are typically small, have simple perforations and alternate intervascular pitting, heterogeneous vascular rays, gummy deposits in the xylem cells and fibers with distinctly bordered pits.

The question remains, however, of whether it is possible to reconcile the alternate leaves, superior ovary (perigynous insertion), few stamens and lack of axial xylem parenchyma with the suggested association of *Heteropyxis* and Myrtaceae. Among the tribes of Myrtaceae, as outlined by Niedenzu (1893), the Leptospermeae, of the subfamily Leptospermoideae, is notable in that some of its members possess one or more of the above features. Indeed, it is here that we find those Myrtaceae with alternate leaves, free ovaries, small numbers of stamens and capsules in which the dried hypanthium remains attached to the fruits. For example: Leaves are alternate in *Callistemon, Kunzea, Leptospermum,* most *Tristania* species, some species of *Metrosideros* and *Eucalyptus,* and many species of *Melaleuca.* Stamens number 5 (opposite the petals) in *Micromyrtus flaviflorus, M. ciliatus* and *Baeckea crassifolia* var. *pentamera;* 10 (opposite each sepal and petal) in *Baeckea ramosissima, B. crassifolia,* and some species of *Micromyrtus.* The ovary is free from the hypanthium in *Metrosideros ornata, M. parallelinervis, M. parviflora, Basisperma lanceolata* (White 1942); partly free (semi-inferior ovary) in *Baeckea, Hypocalymma, Xanthostemon, Backhousia, Calothamnus, Lysicarpus,* etc.

The authors believe, based on the data and observations above, that *Heteropyxis* ought not to be considered as the foundation of a separate family, Heteropyxidaceae. Because of the preponderantly myrtaceous structure, *Heteropyxis* could reasonably be included in Myrtaceae as the basis of a subtribe, Heteropyxineae, under the tribe Leptospermeae of the subfamily Leptospermoideae. As far as the authors can tell at present, the only feature at odds with the suggested inclusion of *Heteropyxis* in Myrtaceae is that no species of Myrtaceae have yet been studied in which axial xylem parenchyma is absent. However, we do know that this characteristic occurs in Punicaceae, a monogeneric myrtalean family, and in *Sonneratia* (Sonneratiaceae) also of the Myrtales. However, the interpretation of the phylogenetic importance of the absence of axial xylem parenchyma is not

clear at present (for comments on the modifications in axial xylem parenchyma see Bailey and Howard 1941, and Kribs 1937).

The principal center of concentration of Leptospermoideae is in Australia with extensions in the Pacific and Indomalesian areas and in Asia proper (Niedenzu 1893). However, there are some remarkable geographic disjunctions in this range: *Metrosideros angustifolia* in the Cape region of South Africa (Niedenzu 1893), and *Tepualia stipularis* in southern Chile and the Argentine-Patagonia area (Niedenzu 1893, Record and Hess 1943). Therefore, to find that *Heteropyxis*, a South African genus, departs from the main center of distribution of the Leptospermoideae should not eliminate the possibility of relationship within that taxon.

SUMMARY

1. The anatomy and taxonomy of *Heteropyxis* have been studied in an effort to determine its affinities, variously reported as with Lythraceae, Myrtaceae, Rhamnaceae and Rutaceae.

2. Original observations on the gross floral and vegetative structure, the anatomy of the petiole, wood and young stem, coupled with data from the literature, show that *Heteropyxis* has definite myrtalean affinities.

3. Because the similarities are so remarkable between *Heteropyxis* and the tribe Leptospermeae of Myrtaceae, it is recommnded that the family Heteropyxidaceae is superfluous, and that *Heteropyxis* should be placed in Leptospermeae as a subtribe, Heteropyxineae.

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ANOTHER STATION FOR GEOCARPON MINIMUM

JULIAN A. STEYERMARK

In the flora of the United States many endemic species have been found, thus far, from only one locality. In monotypic endemic genera the species frequently is known from more than one station (*Nestronia*, *Dionaea*, *Galax*, etc.), or may have even a fairly extensive geographical range (*Orontium aquaticum*, *Calycocarpum Lyoni*, etc.). Those monotypic endemic genera known from only one locality are relatively few, and the genus *Geocarpon* belongs to this rare group.

Described as a new genus in 1914 by Mackenzie (Torreya **14**: 67–68) from plants collected in 1913 and 1914 by Ernest J. Palmer at a station in Jasper County, southwestern Missouri, *Geocarpon minimum* continued to be observed intermittently over the years at this same station by its original discoverer. The original station is confined to a very limited area of ferruginous Pennsylvanian sandstone occurring on the Barton Upland in the unglaciated section of the state. On the exposed outcrops and ledges of this sandstone in an area not over thirty meters in extent occur in scattered abundance numerous plants of this diminutive somewhat fleshy winter annual.

Mackenzie originally placed the genus in the Aizoaceae, and its family position was accepted by later authors until 1950, when Palmer and Steyermark (Bull. Torrey Club **77**: 268–273) transferred *Geocarpon* to the Caryophyllaceae within a new tribe of the family. Palmer and Steyermark had visited the type locality in 1949, and as a result of their critical re-study of living material, they noted the existence of minute staminodial rudiments, a significant diagnostic character overlooked by Mackenzie. This character in *Geocarpon*, combined with the others—lack of stipules, possession of a gamophyllous calyx, 5 perigynous stamens, 1-celled ovary, numerous amphitropous ovules on a free central placenta, and 3 stigmas alternating with 3 tips of the valves of the ovary, provided a combination of morphological distinctions shared by various other genera of the Caryophyllaceae.

In succeeding years a number of interested botanists had contacted Mr. Palmer in order for him to show them this unique locality. However, much to his consternation, Mr. Palmer found this to be an uncertain task. Instead of finding the plants at the station, as he had confidently expected (he and the present author had found living plants in 1949), he was unable to locate any plants. His following letters to the writer express his unsuccessful attempts to re-locate the plants:

"May 15, 1955. On April 30th Dr. and Mrs. Mc Gregor, from Lawrence, Kansas, came down, as he had arranged, to look for *Geocarpon minimum*. I

went to the locality where it was found with a 'fine tooth and comb'. At least we examined a large area on our hands and knees. But found not a single trace of the plant! From the conditions of the associated flora and from previous date records, it seemed that it should have been in its prime. So I am at a loss to understand it. For it is the first time I have ever looked for it without success. Now I am wondering whether it might have come up prematurely early on account of the summer-like weather we had in March, and have been killed by the early April freeze. If that were the case, since it is an annual and depends on seeds for its continued existence, could it be possible that it might have been exterminated by such a catastrophe? It doesn't seem too likely. For if it is an ancient relict, in all probability, it must have survived some equally adverse seasons in the past".

"June 15, 1957. This year I again made three trips up there at different times, and after the abundant rains. And although I went over the ground among the sandstone blocks and in all likely places partly on my hands and knees, I could not find a trace of it. The ground has been cleared of brush and burned over and heavily grazed. And this in connection with the several extremely dry years may account for it. But it would seem that a few stray plants should have survived in the protection of rocks. However, I failed to find one after diligent search . . . I began to fear that it has been exterminated at the type locality".

With such disconcerting news received in recent years, the situation as regards the existence of *Geocarpon minimum* became one of exceeding alarm. During the spring of 1957, while I was botanizing in areas of the unglaciated section of southwestern Missouri, I was en route to a place in St. Clair County known as "Buzzard Bluff". The rocky rutted road traversed a section of sandstone substrata, and at one place this sandstone outcropped prominently in "glades" along a shallow draw of an upland valley tributary to Rattlesnake Branch on the east side of Sac River. Casually stopping to look for any possible records new to St. Clair County, I saw at first the conspicuous bright yellow-orange masses of the crucifer, *Selenia aurea*, and the diffusely cymose white sprays of *Arenaria patula* f. *Pitcheri*. Subsequent botanizing here became a matter of bending closer to the ground to scrutinize more carefully the dwarf plants that comprised the early vernal flora of such an area. Most of the plants were less than one decimeter tall. In addition to *Selenia aurea* and *Arenaria patula* f. *Pitcheri* were such other animals as *Viola Kitaibeliana* var.*Rafinesquii*, *Sedum pulchellum*, *Plantago pusilla*, and *Houstonia minima*, and such perennials as *Selaginella rupestris* and *Nothoscordum bivalve*.

Little by little I proceeded to step from one portion of the sandstone outcrop to another. Thinking to myself that this is a logical sort of situation in which to find *Geocarpon*, I quickly dismissed the thought as just wishful

thinking, for I realized that other botanists, including myself, had searched various sandstone outcrops in Missouri on hundreds of occasions before this. But, as I peered more intently at the dwarf vegetation by my feet, I began to single out certain pale gray-green succulent-like plants. They were only one to two centimeters tall, but they were unmistakable. Most unbelievably, but most certainly, there they were—*Geocarpon*, the long lost *Geocarpon!* My sense of recall immediately flashed back to that day of April 17, 1949, when I had first seen the genus at the type locality, in company with Mr. Palmer. Here now, eight years later and fifty-seven miles (by air) northeast of the Jasper County station, I had discovered the second station known for this monotypic endemic genus.

Warming to the thrill on this solitary event (no other person was along to share this exciting experience), I looked closely, and soon saw many plants distributed over the shallow sandstone soil. The detailed survey which resulted indicated that thousands of plants occurred throughout the area, which, as a whole, was really only a few hundred meters in extent. The occurrence of the *Geocarpon* appeared correlated with the outcropping of the sandstone, and the plants appeared to be distributed along the edge of the moist shallow sandy ground at the border or beginning of the mat of vegetation which pioneered the sandstone outcrops. A tiny rivulet flowed nearby, but not directly on the soil cover inhabited by the *Geocarpon* plants. Concomitant with the first stages of soil formation, these dwarfed plants, which can utilize the thin, almost non-existant soil and survive, are the pioneers of the sandstone. But farther away from the sandstone, where the soil becomes more complex and built up into a deeper structure inhabited by a more crowded flora, no plants of *Geocarpon* were observed.

The collection data are as follows: Missouri: frequent on open sandstone exposures on shallow draw with seepage lines tributary to valley which is tributary to Rattlesnake Branch (tributary to Sac River), T 37 N, R 26 W, SW 1/4 sect. 36, 2 mi. north of Cobb, 7 1/4 mi. (by air) southeast of Roscoe, St. Clair Co., April 24, 1957, *Julian A. Steyermark 83775* (specimens deposited in the herbaria of Chicago Natural History Museum, Harvard University, United States National Museum, Missouri Botanical Garden, New York Botanical Garden).

The discovery of *Geocarpon* at a second station poses a new problem as regards its real distribution and relative scarcity. Why has it not been found previously in all the years of botanizing sandstone or other acidic areas in Missouri? Does the present two-station disrupted distribution present the true picture of its actual distribution, or will future intensive exploration bring out many more stations within this section of the state? In the opinion of this author, my belief is that in the future it will be found at a number of new stations. At first the species had been supposed to have been limited to the Barton Upland in Jasper County, a formation which extends northward

into Barton County. However, with the occurrence of the species at its second station now in St. Clair County, there seems to be no logical reason that it should not be found between the locality in St. Clair County and the one in Jasper County, where numerous sandstone exposures of Pennsylvanian age of similar topographic expression exist to the localities in St. Clair and Jasper counties. The species has a very short growing season, starting in March. After the middle of May, the plant begins to dry up and shrivel, becoming unrecognizable. Apparently, collectors in Missouri, including the present author, have not visited these Pennsylvanian sandstone exposures early enough in the spring, or have not given them sufficiently detailed "on hands-and-knees" exploration at that time of year. In twenty-five years of intensive collecting in Missouri, I have made visits to these Pennsylvanian sandstone areas usually between May and October, and by the time I had visited them in May, it was already too late for finding *Geocarpon*. As the principal and particular type of Pennsylvanian sandstone involved is the Clear Creek member of the Cherokee Formation, which in the unglaciated southwestern section of Missouri outcrops in Barton, Vernon, Cedar, St. Clair, Dade, and Henry counties, it would seem probable that *Geocarpon minimum* may be found eventually in all these counties.

Summary

1. *Geocarpon* is a monotypic endemic genus, its species, *G. minimum*, having been previously known but from one locality in Jasper County, Missouri.

2. Recent attempts to locate it at the type locality have failed.

3. A second station was discovered during 1957 in St. Clair County, fifty-seven miles (by air) northeast of the original station.

4. Because of the duplication of the particular Pennsylvanian sandstone, upon which the St. Clair County discovery was made, over a relatively wide area, encompassing several other counties, it is believed that the species will eventually be found in such areas of sandstone of similar topographic expression to those where it has already been found.

5. The belief is expressed that the plants have been overlooked by previous botanists, because search has not been made early enough in the year (March to late April) when the plants are evident, and because insufficient botanizing at that time of year on sandstone exposures has been done close to the ground in detail.

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THE SEPARATION OF CHLOROPLAST PIGMENTS BY UNIDIMENSIONAL ASCENDING PAPER CHROMATOGRAPHY

FREDERICK T. WOLF

The separation of chloroplast pigments by means of paper chromatography has received considerable attention in recent years. In an early study, Brown (1939) was able to separate chlorophyll *a*, chlorophyll *b*, and carotenoids on circular paper chromatograms with carbon disulphide as the developing solvent. Bauer (1952), employing the unidimensional ascending technique, separated six components, including chlorophyll *a*, chlorophyll *b*, carotene, xanthophyll, and xanthophyll epoxide, with a variety of solvents. Acetone or benzene was unsatisfactory, and resulted in little or no separation. Better results were obtained with petroleum ether or methanol, and monochlorobenzene or toluene gave excellent separation. For bidimensional chromatograms, Bauer recommended development in one direction with a mixture of benzene, petroleum ether, and acetone, 10:2.5:2 parts by volume, and in the other direction with benzene, petroleum ether, acetone, and methanol, 10:2.5:1:0.25.

Aromatic hydrocarbons and carbon tetrachloride proved to be the best of a number of solvents tested by Asami (1952). Satisfactory separation of the chloroplast pigments was obtained using methanol, 80 per cent methanol, benzene, toluene, xylene, carbon tetrachloride, and a 1:1 mixture of benzene and petroleum ether.

Douin (1953, 1956) used methanol as the developing solvent, and applied this method to studies of the pigments of mosses. R_F values typical of his work are 0.40 for carotene, 0.54 for chlorophyll *a*, 0.60 for chlorophyll *b*, 0.61 and 0.66 for xanthophylls. Sironval (1953) used descending paper chromatography with a solvent mixture of benzene, petroleum ether, and acetone, 10:2.5:2, as recommended by Bauer (1952).

Lind, Lane, and Gleason (1953) employed a bidimensional technique, using acetone, petroleum ether, or petroleum ether containing 1 per cent *n*-propanol in the first dimension, and petroleum ether containing 25 per cent chloroform in the second. Strain (1953) obtained excellent separations with petroleum ether, or petroleum ether containing 0.5 per cent *n*-propanol. By impregnating the papers with vaseline and developing with 80 per cent methanol, reversal of the sequence of zones on the chromatogram resulted. Greulach (1953) recommended petroleum ether containing 1 per cent methanol as the solvent mixture. Similarly, a 50:1 mixture of petroleum ether and methanol was recommended by Meyer, Anderson, and Swanson (1955).

Chiba and Noguchi (1954), attempting to separate chlorophylls *a* and *b* using toluene as recommended by Asami (1952), obtained low R_F values in the pure solvent. Upon addition of ethanol, 1 part in 200, the R_F values were increased, and better separation resulted. Sporer, Freed, and Sancier (1954) impregnated the paper strips with sucrose, and developed the chromatograms in the dark, at reduced temperature, and in a nitrogen atmosphere. Chlorophylls *a* and *b* were separated in a solvent mixture of 0.5 per cent *n*-propanol in *n*-hexane.

Hager (1955, 1957) used a mixture of petroleum ether, benzene, chloroform, acetone, and isopropanol, in the ratio 50 : 35 : 10 : 0.5 : 0.17. He obtained separation of numerous zones, including the phaeophytins and phaeophorbides, chlorophylls *a* and *b*, two known and three unidentified carotenes, and seven known and three unidentified xanthophylls from plant material.

It is the purpose of this paper to compare certain of the methods advocated by previous workers for the separation of chloroplast pigments employing unidimensional ascending paper chromatography. In addition, data are presented concerning a number of solvents which have not been previously used for this purpose.

Materials and methods. Leaves of spinach, *Spinacia oleracea* L., obtained at a local market, served as the usual source of plant pigments. Leaves of plantain, *Plantago major* L., were also used to a lesser extent.

The leaves were placed in a Waring blendor, a pinch of $CaCO_3$ was added, and the pigments were extracted with acetone. The pigments in acetone solution were transferred to ether in a separatory funnel. The ether solution of the pigments was washed repeatedly with water, and was dried by the addition of anhydrous Na_2SO_4.

Graduates of 500 ml. capacity were used as chromatographic chambers. These were fitted with rubber stoppers, pierced with a paper clip so as to provide a means of suspending the paper strips. Whatman number 1 paper strips measuring 1½ by 12½ inches were used in all experiments. The ether solution of the pigments was applied to a small circular spot, one inch from the bottom of the paper strip, by means of an ultra-micro volumetric pipette.

Development of the chromatograms was allowed to proceed under uncontrolled temperature conditions in the laboratory. In a few instances when prevailing temperatures were high, the chromatograms were developed in a constant temperature room maintained at 20–22°C.

Results. A large number of solvents and solvent mixtures which were tested failed to resolve the pigments. When water or ethylene glycol was used as the developing solvent, there was no migration of any pigment, all of the substances remaining at the point of origin. With various alcohols,

including ethyl alcohol, *n*-propyl alcohol, isopropyl alcohol, *n*-butyl alcohol, isobutyl alcohol, tertiary butyl alcohol, *n*-amyl alcohol, and isoamyl alcohol, all of the pigments migrated with the solvent front, so that no separation resulted. Similar results were obtained with acetone, methyl ethyl ketone, ethyl acetate, butyl acetate, benzene, carbon disulphide, chloroform, ether, pyridine, lutidine, collidine, 1, 4 dioxane, triacetin, and ethylene glycol monoethyl ether. With a 10:2.5:2 mixture of benzene, petroleum ether, and acetone, as used by Bauer (1952) and Sironval (1953), no separation resulted in our trials.

With 1, 3 butanediol or 2, 3 butanediol, some degree of separation could be obtained. In 1, 3 butanediol, for example, the xanthophyll component with an R_F of 0.76–0.87 is well separated, but development is very slow, requiring 16–18 hours, and the colors tend to fade badly, so that these solvents cannot be recommended for general use.

In considering some 16 solvents and solvent mixtures which yielded good separations, four patterns of separation became apparent. In each case, the components are named in the order of increasing R_F. The types of separation found are as follows:

1. The *c*, (*a plus b*), *x* type, in which carotene and xanthophyll are well separated from each other and from the chlorophylls, but resolution of chlorophylls *a* and *b* does not occur.
2. The *b*, *a*, (*c plus x*) type, in which chlorophylls *a* and *b* are separated from each other and from the carotenoids, but separation of the carotene and xanthophyll fractions does not occur.
3. The *b*, *a*, *x*, *c* type, in which resolution of four components occurs, and
4. The *b*, *x*, *a*, *c* type, likewise resulting in the separation of four components, but in a different order. The four types of separation will now be discussed separately.

The c, (a plus b), x type. This type of separation results from the use of methanol, propylene glycol, or diethylene glycol as the developing sol- chloroplast pigments by Asami (1952), Bauer (1952), and Douin (1953, 1956). No previous information concerned with propylene glycol or diethyl- vent. Methanol has previously been used in the paper chromatography of ene glycol has been found. Douin (1953, 1956) was able to separate chlorophyll *a* and chlorophyll *b* with methanol, a result at variance with the findings of Bauer (1952) and with those of the present study. The R_F values found are presented in Table 1, in which each value presented is based on 4–6 separate experiments.

The high R_F values for xanthophyll obtained in these solvents doubtless result from the possession of an hydroxy group in common with the solvents. The chlorophylls covered such a wide area on the chromatograms

that their R_F is presented in the form of extremes, rather than an average which would be misleading. No separation of chlorophyll *a* from chlorophyll *b* was noted. The slowness of development with propylene glycol or diethylene glycol, requiring approximately 18 hours, together with the hygroscopic character of these substances, resulting in difficulty in drying the paper strips, are definite disadvantages to their use.

The b, a, (c plus x) type. When toluene-ethanol 200:1 or *o*-dichlorobenzene is used as the developing solvent, chlorophylls *a* and *b* are separated from each other, but the less highly adsorbed carotenoids are not resolved. The toluene-ethanol mixture was proposed by Chiba and Noguchi (1954) in an effort to bring about better separations of chlorophylls *a* and *b* than resulted in pure toluene. *o*-Dichlorobenzene has not been previously studied in relation to the separation of plastid pigments.

TABLE 1. *R_F values of chloroplast pigments in various solvents*

Solvent	R_F					
	chlorophyll *b*	chlorophyll *a*	chlorophylls *a* + *b*	xanthophyll	xanthophyll + carotene	carotene
Petroleum ether	0.12	0.24	—	0.59	—	1.00
Cyclohexane	0.14	0.36	—	0.70	—	1.00
Methyl cyclohexane	0.14	0.39	—	0.78	—	1.00
Xylene	0.34	0.48	—	0.87	—	1.00
Toluene	0.42	0.59	—	0.87	—	1.00
Carbon tetrachloride	0.32	0.52	—	0.87	—	1.00
Monochlorobenzene	0.49	0.63	—	0.92	—	1.00
Benzene-pet.ether 1:1	0.15	0.26	—	0.90	—	1.00
Hager mixture	0.46	0.74	—	0.92	—	1.00
Pet. ether + 1% methanol	0.37	0.83	—	0.65	—	1.00
Pet. ether + 0.5% *n*-propanol	0.23	0.78	—	0.49	—	1.00
Methanol	—	—	0.73	0.89	—	0.51
Propylene glycol	—	—	0.13–0.74	1.00	—	0
Diethylene glycol	—	—	0.12–0.77	1.00	—	0
Toluene-ethanol 200:1	0.55	0.76	—	—	0.94	—
o-Dichlorobenzene	0.43	0.61	—	—	1.00	—

The b, a, x, c type. Nine solvents and solvent mixtures gave separations in which the two chlorophylls, carotene, and xanthophyll are resolved. These were petroleum ether, cyclohexane, methyl cyclohexane, xylene, toluene, carbon tetrachloride, monochlorobenzene, benzene-petroleum ether 1:1, and petroleum ether, benzene, chloroform, acetone, isopropanol mixture, 50:35:10:0.5:0.17. Petroleum ether has been previously used in chloroplast pigment chromatography by Bauer (1952) and Strain (1953). Cyclohexane and methyl cyclohexane have not previously been tested for these separations. Xylene gave good separations according to Asami (1952). Toluene gave good separations in the work of Asami (1952), Bauer (1952),

and Chiba and Noguchi (1954). Carbon tetrachloride has been used in plant pigment chromatography by Asami (1952), monochlorobenzene by Bauer (1952), benzene-petroleum ether 1:1 by Asami (1952), and the petroleum ether, benzene, chloroform, acetone, isopropanol mixture, 50:35:10:0.5:0.17 by Hager (1955, 1957).

Good separations were routinely obtained with almost all of the solvents and solvent mixtures of this group. Occasional trials with toluene and monochlorobenzene resulted in failure of separation of xanthophyll and carotene, for a reason we are unable to explain. With spinach leaves, the xanthophyll fraction was resolved by petroleum ether into two components, one lying immediately above chlorophyll *a*, the other considerably above chlorophyll *a* and well separated from both this pigment and carotene.

The b, x, a, c type. When petroleum ether plus 1 per cent methanol (Greulach 1953) or petroleum ether plus 0.5 per cent *n*-propanol (Strain 1953) was used as the solvent mixture, the relative positions of chlorophyll *a* and xanthophyll on the chromatograms, as compared to pure petroleum ether, are reversed. The hydroxyl group of the alcohol in the solvent mixture decreases the adsorption of xanthophyll. With spinach leaves, in some instances the xanthophyll fraction was resolved into two components, one below and one above chlorophyll *a*.

Discussion. Partial separation of chlorophyll *a*, chlorophyll *b*, carotene, and xanthophyll was given by five of the solvents or solvent mixtures tested, and complete separation of these four pigments resulted in eleven different solvents or mixtures. In every case in which chlorophyll *a* and chlorophyll *b* were separated, the R_F of chlorophyll *b* was found to be lower than that of chlorophyll *a*. In general, the R_F values of the carotenoids are higher than those of the chlorophylls in hydrocarbon or chlorinated hydrocarbon solvents, in which carotene is usually to be found at the solvent front, and xanthophyll lies between chlorophyll *a* and carotene. In solvents or solvent mixtures containing an hydroxyl group (alcohol or glycol), the R_F of xanthophyll is greater than that of carotene.

The foregoing experiments have demonstrated a number of ways in which the leaf pigments may be easily and rapidly separated by means of paper chromatography. The choice of the method to be preferred may conceivably vary with the purposes of the particular investigation. Any of them are suitable for the classroom demonstration of the presence of chlorophylls and carotenoids in plant materials.

SUMMARY

1. The paper chromatographic separation of chloroplast pigments has been studied with 43 different solvents and solvent mixtures. Developing solvents recommended by previous workers were studied comparatively,

and a number of solvents not previously used for this purpose were also examined.

2. Sixteen of the solvents and solvent mixtures gave satisfactory separation of the chloroplast pigments.

3. According to the type of separation produced, the solvents and solvent mixtures may be classified into four types.

4. Solvents which may be used for paper chromatography of chloroplast pigments include propylene glycol, diethylene glycol, *o*-dichlorobenzene, cyclohexane, and methyl cyclohexane, none of which have been previously used for this purpose.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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ATTEMPTS TO FREEZE-DRY PINE POLLEN FOR PROLONGED STORAGE

C. W. HESSELTINE AND E. B. SNYDER

Attempts were made by the authors to freeze-dry pollen of longleaf pine (*Pinus palustris* Mill.). Breeding would be greatly facilitated if this and pollen of other species could be stored for one year or more. However, treatments by which fungus spores have been stored successfully for 15 years according to Mehrotra and Hesseltine (1957) failed with the pine pollen. A report of the details followed may save others from fruitlessly repeating identical treatments.

Pollen collected in southern Mississippi in late April 1955 and shipped to Peoria, Illinois, was lyophilized in a manner similar to that used for fungus spores by Raper and Alexander (1945), *i.e.*, suspended in Seitz-filtered bovine serum, freeze-dried, and sealed in vacuum. While germination of the lyophilized material was zero, that of the untreated pollen was good when tested shortly afterwards.

Because germination of pine pollen is often induced in concentrations of sucrose, a new sample was suspended in solutions of 6 per cent dextran, 2 per cent sucrose, 5 per cent sucrose, 10 per cent sucrose, and 20 per cent sucrose. Six tubes were prepared for each treatment. Other conditions were the same. Germination was zero for the treated pollen; it was 60 to 70 per cent for untreated checks.

The next year new pollen was lyophilized with freezing at – 15° C using six modifications of the suspending agent: serum plus 2 per cent glucose, serum plus 4 per cent glucose, serum plus 8 per cent glucose, dry milk powder plus 2 per cent glycerol in water, and serum only. Melting of the pellet in the lyophil tubes caused difficulty with the dry milk plus glycerol and with the 8 per cent glucose. While controls gave germination of 50 to 82 per cent, the lyophil preparations gave none, although there was a slight bulging of the grains in the 4 per cent and 8 per cent glucose series. The above experiment was repeated using 4, 8, and 10 per cent glucose and serum with negative results.

Rehydration variations applied to the treated pollen included exposure to 65 per cent relative humidity at 5° to 10° C for one week, to 100 per cent relative humidity at 5° to 10° C for a day, and suspension in USP liquid petrolatum for 20 minutes. Germination tests were conducted after 72 hours at 28° C both on 0.7 per cent agar containing 10 per cent sucrose and in distilled water.

Lyophilization was carried out at the Northern Regional Research

Laboratory, Peoria, Illinois, and rehydration and germination testing at the Southern Institute of Forest Genetics, Gulfport, Mississippi. Mrs. Jane A. Roberson assisted in making the lyophil preparations.

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AND

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SOME EFFECTS OF TEMPERATURE ON POLLEN CHARACTERS

EDWIN B. KURTZ, JR. AND JAMES L. LIVERMAN[1]

The external characters of pollen, such as diameter, size and number of furrows and pores, and sculpturing of the exine, are widely used for identification purposes. Yet it is recognized that these characters are more or less variable, particularly as a result of climatic effects on the pollen-forming plant or directly upon pollen formation. Thus it is customary in the description of a pollen type to present the average size or number of each character. Even size frequency has been used in the identification of pollen of certain genera. Several studies have attempted to demonstrate the relationship between pollen characters and various climatic factors. Thus high temperatures are stated to favor the formation of large pollen grains (Kawecka 1926, Piech 1922, Stow 1930); repeated cooling of flower buds causes the formation of abnormal pollen with a variable number of germ pores (Michaelis 1928); aridity causes small pollen grains (Schoch-Bodmer 1940); position of the flower on the plant, size of the anther, and time of flowering all influence pollen size (Andreev 1934, Mehlquist 1942, Schoch-Bodmer 1940); and Mikkelsen (1949) concluded that nutrition had such a marked influence on the plants and pollen in his studies that only limited conclusions about temperature effects on pollen could be obtained.

The purpose of this paper is to demonstrate some effects of controlled temperature on pollen characters of tomato and cocklebur.

Methods and results. Tomato (*Lycopersicon esculentum*) and cocklebur (*Xanthium canadense*) plants were grown in the Earhart Plant Research Laboratory (Went 1957) under controlled day and night temperatures and photoperiod (8-hour natural daylight, 16-hour night). We wish to thank Dr. F. W. Went for providing the tomato plants used in this study. Because pollen was collected at random from several flowers from each of four plants growing in each environment, genetic and positional effects on pollen characters have been minimized. Pollen was mounted in glycerine jelly stained with aqueous fuchsin (Wodehouse 1935) and all measurements were made in microns at a magnification of either 440× or 980×. Only fully expanded grains in polar view were measured.

As shown in figure 1, the diameter or growth of tomato pollen is influenced by night temperature quite similarly to the growth of plants under

[1] This work was begun while E.B.K. was a National Research Council Predoctoral Fellow and J.L.L. was a Lucy Mason Clark Predoctoral Fellow at the California Institute of Technology.

these same conditions (Went 1957). There was no variation of exine characters at any temperature, but a small percentage of tetracolpate grains occurred at the highest temperatures whereas all other grains were tricolpate.

Similar results in regard to night temperature were obtained with cocklebur pollen, although the size at 30° day temperature was quite variable (fig. 2). Moreover, pollen size increased with decreased day temperature, which agrees with Mikkelsen's (1949) work on *Pelargonium zonale*. No effects of temperature on the exine or furrow number were observed. Pollen size of cocklebur was also studied in relation to site of forma-

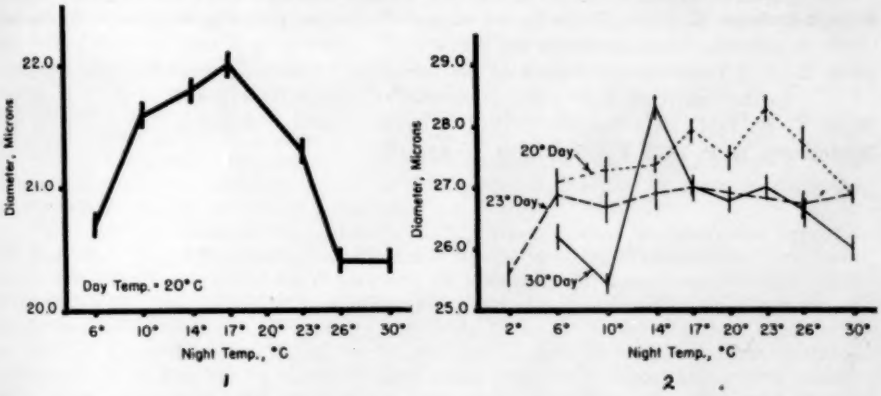

FIG. 1. Effect of night temperature on the diameter of tomato pollen. Each vertical bar represents one standard deviation from the mean of 20 measurements. FIG. 2. Effect of day and night temperatures on the diameter of cocklebur pollen. Each vertical bar represents one standard deviation from the mean of 30 to 50 measurements.

tion on the plant. Generally pollen was largest in terminal flowers or in flowers formed just behind the apex, which disagrees with Andreev (1934) but agrees with Schoch-Bodmer (1940).

SUMMARY

1. The effect of temperature on pollen size and exine characters of tomato and cocklebur was studied under controlled climatic conditions.

2. Day and night temperatures had little effect on exine characters, but diameter of pollen decreased at high and low night temperatures and at high day temperatures.

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TORREYA

Elsholtzia Ciliata in New York

JOSEPH MONACHINO

The Asiatic weed *Elsholtzia ciliata* (Thunb.) Hylander was first reported for the New World in 1889 (Bull. Torr. Bot. Club **16**: 243). This first record was based on collections made by J. I. Northrop in 1887 and 1889 in the little village of Notre Dame du Lac, in a clearing near a mill, in one place near the shore of Lake Temiscouata, Quebec, Canada. Dr. Northrop (1890) noted that the plant was evidently well established and added that there was "no record of its ever being cultivated, and how it reached this out-of-the-way spot is a mystery." The colony has remained on the site for a long time; in 1944 Clarance Hinckley stated that Fernald reported the species still flourishing in recent years at this locality. In 1910 the species was reported by Fernald and Wiegand as abounding in gravel about the railroad yard at New Limerick, Maine. Hinckley (1944) recorded a collection made in 1938 in a dooryard at Chelsea, Orange Co., Vt., and one made in 1943 in Eastern Massachusetts, close to the sidewalk in an ill-kept dooryard near Liberty School at Revere Beach. Neither of these was noticed by Fernald in his 8th Ed. Gray's Manual.

Until now the Eastern Massachusetts station was the most southerly one reported for America.[1] The present collection was made by the writer in Inwood Hill Park, near the 207th Street entrance, on September 28, October 26 and November 16, 1957 (*Monachino 615, 617, 619*), on a gentle, rather dry slope, semishaded by a canopy of chiefly red and white oaks. The colony was quite dense and covered almost exclusively an area of approximately 25 feet in length and 15 feet in width; a few scattered individuals were seen up to about 40 feet away. The main associated plants nearby were *Aster divaricatus*, and stubbles of *Viburnum acerifolium*, *Sasafras* and *Carya*. On September 28 the plants were in young bud, on October 26 in flower and bud, and on November 16 in fruit.

On the last visit the soil around the plants was thickly blanketed by a litter of oak leaves, mostly red and some white. *E. ciliata*, as seen at Inwood, is a shallow-rooted annual, less than 3 feet tall; when the stem becomes accidentally decumbent at the base, it roots where it touches the soil. The general appearance has been aptly described as that of an *Acalypha;* it also suggests a dwarf *Agastache;* it is weedy and unornamental. The flowers from bud to maturity and the slightly gibbous-curved fruiting calyces are secund; the inconspicuous corollas are light lavender, the anthers yellow. The young stobile-like spikes are slightly arching-nodding at the apex. The plant branches generously to below the middle and practically every branch terminates in a spike, so that there may be up to about 50 spikes on one individual. The scent has been described as lemon-like; but to the writer, the minty subfetid ordor of the crushed plant is nothing like that of the Bee Balm.

The puzzlement Dr. Northrop (1890) first expressed regarding the appearance of the weed at Temiscouata Lake is shared by us: how it reached the spot in Inwood Hill is indeed a mystery. I have never seen *E. ciliata* cultivated in the New York City area

[1] In answer to inquiry whether *E. ciliata* has been collected in New York State, Stanley Jay Smith, New York State Museum and Science Service, The University of the State of New York, wrote on January 7, 1958: "We have a specimen in the herbarium collected in Oswego by a Mr. Charles S. Sheldon in 1881. According to him, Father J. Herman Wibbe considered it naturalized near Oswego, but this particular specimen came from Father Wibbe's garden. Mr. Theodore C. Baim collected it in Schenectady in 1946 (Baim 1928) and again in 1949 (Baim 3077). This latter year, it was also collected in Scotia, across the Mohawk from Schenectady (Baim and Smith 6258)."

or elsewhere. Its ungainly appearance, ill scent and uselessness would hardly induce cultivation. However, it should be noted that the species is entered in Bailey's Hortus Second.

The habitat is specified as "moist soil" in Gleason's New Britton and Brown, but there is no support for assuming this restriction regarding places where it will grow. In its native range in Asia, *E. ciliata* has been collected "on exposed rocky slope," "open hillsides," "roadside," "stony pastures and cultivated fields," in "temple yard" and "dry sandy soil."

The writer has been the first to collect various species, mostly weeds, in the New York area; for example, *Epichloë typhina, Sarcosphaera ammophila, Arthraxon hispidus* var. *cryptatherus, Calamogrostis epigeios, Elymus arenarius, Panicum scoparium, Alchemilla microcarpa, Herniaria glabra* var. *subciliata, Silene cserei, Bassia hyssopifolia, Lepidium latifolium, Rorippa indica, Photinia villosa, Dolichos lablab, Geranium nepalense* var. *thunbergii, Elatine triandra, Jussiaea uruguayensis, Cynanchum medium, Solanum sarachoides, Iva xanthifolia, Guizotia abyssinica, Madia capitata, Lactuca pulchella.* These previous collections were not too remarkable, and neither is the present discovery of *E. ciliata,* though, of course, quite interesting as a new record. All of them were readily spotted as new, without exercise of any extraordinary botanical acumen or study of obstruse characters. An evident conclusion can be drawn: after acquiring a basic knowledge of the local flora, anyone can add somewhat to our list of new weed records by devoting even passing attention to the wayside plants.

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PROCEEDINGS OF THE CLUB

OCTOBER 1, 1957. The meeting of the Club at the New York Botanical Garden was called to order by President Rickett at 8:00 P.M. There were 46 members and guests present. The minutes of the May 21st, 1957 meeting were approved as read. The following were elected to Active (Annual) membership in the Club: David W. Bierhorst, Neal Buffaloe, and Phillip J. Halicki, and the following to Associate Membership: Helen A. Berger, Dorothy S. Chapple, Ta Kwong Lee, Saul Minsky, and Florence von Henkel. The resignations of the Rev. Yvan Carrier and Dr. Jean MacMahon Murphy were accepted with regret.

Dr. Rickett announced that due to the election of Dr. Robert Lampton to the office of Vice-President, a vacancy existed on the Council and requested nominations. Miss Hollinghurst, seconded by Mr. Lehr, proposed the name of Dr. Eleanor Witkus. Dr. Lawton moved that the nominations be closed and the Secretary be instructed to cast one ballot for the election of Dr. Witkus. The motion was unanimously passed by the Club.

President Rickett then introduced the speaker of the evening, Mr. A. Clayton Scribner, who spoke to the Members on, "Wild Flowers of the Canadian Rockies." Mr. Scribner illustrated his talk with handsome colored slides of the flora and fauna of the Bow Lake Area, The Columbia Ice Field, Lake O'Hara, Mount Wilcox and other areas of the Canadian Rockies.

The meeting was adjourned at 8:50 P.M. after which refreshments were served by members of the Garden staff.

Respectfully submitted
Frank G. Lier, Rec. Sec'y

OCTOBER 19, 1957. During the afternoon, the members of the Club were taken on a conducted tour of the William T. Davis Wildlife Refuge by Miss Mathilde P. Weingartner and other members of the Staten Island Museum. After a pleasant walk through the Refuge, the Club members returned to the Staten Island Museum Building for excellent refreshments served by Miss Weingartner and her group.

The meeting of the Club was called to order by President Rickett at 5:00 P.M. with 30 members and guests present. The minutes of the October 1, 1957 meeting were approved as read. Mrs. Lucia Andrews was elected to Active (Annual) Membership and Mr. Lincoln Adderley to Associate Membership in the Club.

Dr. Rickett called for a report from the Nominating Committee on the slate of Officers for 1958 as required by the Constitution. No member of the committee was present and efforts to get in touch with one of them proved to no avail. Most of the names of those nominated for office in 1958 were recalled by those present, however, so that the requirements of the constitution were considered to have been met.

Mr. Joseph Burke announced to the Club the passing away of Mr. Isaiah Cooper, Davis Curator of the Staten Island Museum and member of the Torrey Botanical Club. Mr. Cooper had been very active in making a survey of the Staten Island Flora and in a study of the insects of the area.

Dr. Rickett, in behalf of the Club, thanked Miss Weingartner and Mr. Fred W. Hopping for their hospitality and the enjoyable visit to the Wildlife Refuge during the afternoon.

Nominations for Council Members were then requested by Dr. Rickett. Miss Mathilde P. Weingartner was nominated and then a motion was made by Dr. Clyde Chandler that nominations be closed. This was passed by the members.

During the remainder of the meeting, several Club members told of their summer experiences. Dr. Peter Nelson showed colored slides of flowers in the vicinity of Nassau in the Bahamas. Mr. Walter W. Shannon described some of his experiences on the islands of Saint Pierre and Miquelon. Miss Weingartner showed some slides of the flora around Litchfield, Connecticut, Mount Desert Island and Mount Katahdin in Maine. Dr. John Small and Mr. Lee A. Ellison told of their visit to Mount Katahdin and Mount Desert Island. Their talk was well illustrated with colored slides. Dr. Rickett showed some of the pictures he had taken during his visit to England in the spring.

The meeting was adjourned at 6:30 P.M.

Respectfully submitted
Frank G. Lier
Recording Secretary

Book Reviews

Plant Diseases Due to Bacteria. By W. J. Dowson. Second Edition + 232 pages. New York: Cambridge University Press. 1957. $6.50.

The format of this second edition of bacterial plant diseases is essentially the same as the first edition which appeared in 1949. The terminology is simply maintained as in the first edition which is an aid to those with a limited background in bacteriology. Newly added to this edition are, discussions of 20 more diseases, one of which was originally thought to be caused by a virus, the use of antibiotics as a supplement to control practices, an entirely new chapter on preserving cultures, and 3 additional maps (making a total of 21) showing the geographical distribution of diseases.

The book contains 13 chapters divided into 3 parts. The first part consists of 4 chapters which deal with general bacteriology, including the bacteriophage; classification and nomenclature, with a brief discussion of older systems of classification; general

symptoms of bacterial diseases and the effects of association of other organisms on disease expression; and a discussion of methods for investigating bacterial diseases (Koch's postulates).

Part II contains 3 chapters dealing with the "mechanics" of handling bacteria—general and specific media with directions for preparing them, staining techniques, and certain physiological and biochemical activities of bacteria and how these aid in the identification of species.

The remaining 6 chapters, in Part III, are devoted to discussion of diseases and the preservation of bacterial cultures. The genera *Corynebacterium*, *Pseudomonas* and *Xanthomonas* are treated, respectively, in Chapters 8, 9 and 10. In chapter 11, Dr. Dowson, in view of the invalidation of the genus *Bacterium* by the International Congress for Microbiology in 1953 and the lack of proposals for its replacement, suggests the "temporary" use of the genus *Pectobacterium* for those coliform plant pathogens which produce gas from sugars, and possess pectic enzymes, and *Erwinia* (including *Agrobacterium*) for those which have neither characteristic. The salient features of each genus and type species are given followed by a discussion of individual diseases which are grouped according to type, *i.e.* parenchyma, systemic, vascular and hyperplastic.

Miscellaneous bacteria, including some saprophytes, are discussed in chapter 12.

The final and newly added chapter deals with several methods of preserving bacterial cultures to maintain their identity "for a year or more without sub-culturing."

As in the first edition, references of source material are cited after pertinent sections. Also, the suggestions for reading, photographs, and maps showing the geographical distribution of bacterial diseases are included at the end of the book.—RAYMOND CAPPELLINI, Department of Plant Pathology, Rutgers, The State University of N. J., New Brunswick, N. J.

Die Gattungen der Rhodophyceen. By Harold Kylin. Gleerup, Lund, Sweden. xv + 673 pp., 458 figs. 1956[1]. Cloth 135 Sw. Kr.; paper 125 Sw. Kr.

It is indeed fortunate for botany in general and algology in particular that the world's most distinguished student of the red algae agreed to prepare a volume on the genera of this group and that he was able to complete it.

The original plan was to publish the work as a volume in the second edition of Engler and Prantl's DIE NATÜRLICHEN PFLANZENFAMILIEN. The manuscript was completed in 1944 but the war prevented its publication at that time. Kylin kept it up to date until June 1949. After his death in December 1949, his wife, Elsa Kylin, obtained support for its publication and obtained a publisher in Sweden. We owe Mrs. Kylin a special debt of gratitude for her devoted labor in seeing the work through the press. She not only attended to all the details connected with the printing of the book but prepared the excellent indices of scientific and author's names and an extensive supplement (pp. 563–592) which incorporates material published from 1949 to the end of 1954. (Attention should be called to the new combinations under *Corynospora* on page 583, which will have to be credited to Elsa Kylin and not to H. Kylin.)

The volume begins with a brief characterization of the Rhodophyceae and a useful general account of the structure and chemistry of the rhodophycean cell. In error, these algae are stated to possess chlorophylls *a* and γ (now *c*) instead of *a* and *d*. In the systematic part, the two subclasses Bangiophycidae and Florideophycidae are characterized and discussed in some detail with respect to their features of structure and reproduction and as to their phylogeny. For the Bangiophycidae, which is a relatively small group, a single key is given for the orders, families and genera, whereas separate keys are provided for the orders, families and genera of the Florideophycidae. The orders and families are briefly characterized and the families are discussed—in many instances in considerable detail—with respect to structure, reproduction, geographic distribution, and, in some instances, relationship. A noteworthy feature is the citation of the authors, and date of publication, of the orders and families, information which

[1] The actual date of publication is October 30, as I have been informed by Mrs. Kylin.

usually is not given in works of this kind. In a number of instances, however, the author or date given is incorrect, as for example, in the case of Lemaneaceae (described by Rabenhorst in 1863), Helminthocladiaceae (described by Hauck in 1883), Chaetangiaceae (described by Hauck in 1883), Hildenbrandiaceae (described by Rabenhorst in 1868), and Rhodomelaceae (described by Harvey in 1849).

For the genera, in addition to the diagnosis, the author and date of publication and other important references are cited. The type or lectotype of almost all the genera accepted (568) is indicated and the synonyms (but not always all of them) of the genera are given. The approximate number of species in each genus and its geographic distribution are also indicated. It should be noted that some of the families and almost all the genera attributed by Kylin (and by some other authors) to Schmitz as of 1889 were *nomina nuda* in that publication. The erroneous acceptance of 1889 as the date of validation of these genera has resulted in at least one case in the suppression of the correct name: *Gloiophyllis* J. Agardh (1890) is the correct name for *Grunowiella* Schmitz. In a number of instances the type or lectotype species cited is not the correct one, as in the case of *Polysiphonia* and *Aneuria*, whose types (as given by Kylin) were not included in the genus or subgenus (*Aneuria*) when it was established.

Many decisions of a taxonomic nature are published for the first time in this book: sixteen new genera are described, for a few genera new names are proposed, a few that had been reduced are resurrected, others are reduced, many new combinations are made, and a number of genera are transferred to different families than those in which they had been placed. The bases for some of these changes are not as firm, however, as is desirable. It might be pointed out that *Implicaria* Heydrich, which Kylin accepts, has been shown by Okamura (1936) and Segawa (1939, 1941) to be congeneric with *Vanvoorstia* Harvey, and *Duthiea* Manza should be known as *Duthiophycus* Tandy (1938). In a number of instances the nomenclature adopted is in violation of the Code. Thus, for example, Kylin retains the name *Acrosymphyton* Sjöstedt (1926) despite the fact that he has found it to be congeneric with *Helminthiopsis* J. Agardh (1899).

The present system of classification of the major group of the red algae, the Florideophycidae, was ushered in by Schmitz in his epoch-making paper of 1883. Oltmanns in 1904 made the first major emendation in this system and Kylin further refined it in an important series of publications that culminated in his monograph on the order Gigartinales in 1932. Despite certain shortcomings, Kylin's system of 1932 presents a much more natural arrangement of these algae than had previously been possible. It is the standard one today and is maintained in this volume. The classification of the Bangiophycidae that Kylin has adopted is essentially the one proposed by Skuja in 1939.

Although Kylin suggests in the present volume certain regroupings of genera in the families Ceramiaceae, Delesseriaceae and Rhodomelaceae of the order Ceramiales, no major changes in the system are proposed. Those who had hoped to see radical changes in the system will thus be disappointed. It is highly probable that this system is as yet imperfect, but much further work on the morphology and the life histories of the red algae is necessary before it will be possible to make significant changes.

For almost sixty years the only work on the genera of red algae in a modern language has been the treatment by Schmitz and Hauptfleisch (1896–1897) in Engler and Prantl's DIE NATÜRLICHEN PFLANZENFAMILIEN, to which Svedelius prepared a supplement in 1911. The great advances that have been made in knowledge of the morphology and taxonomy of these algae during the past fifty years, contributed in large measure by Kylin, have rendered Schmitz and Hauptfleisch's work completely out of date. Kylin's GATTUNGEN DER RHODOPHYCEEN thus forms a most welcome contribution to organized knowledge of this extremely difficult group of plants. The large number of illustrations (over 2100 individual figures) and the extensive bibliography of over 1700 cited references further enhance the value of this excellent volume.

There is no doubt that this book will be a great stimulus to work on the red algae. As a former student of Professor Kylin, I know that the highest reward that he would have liked for his labors would be, for this, his last work, soon to become obsolete as a result of the intensive studies certain to be inspired by it.—GEORGE F. PAPENFUSS, Department of Botany, University of California, Berkeley.

Pollen Grains of Japan. By Masa Ikuse. Hirokawa Publishing Company, Tokyo. Color frontispiece, pp. xi + 301, 76 plates. 1956. $15.00.

This book presents a classification of modern pollen based upon morphological groupings into 65 pollen types. The heart of the classification is a chart (fig. 2) which shows the pollen types of the respective groups. These groups are not named but are designated by numbers and letters. The ordinate is numbered from 1 to 8 and the abscissa is lettered from A to D. Within the major categories the pollen type is designated by superscript letters. Thus $6A^a$ is a triporate grain with pores in the sides whereas $6A^b$ is a triporate grain with pores in the angles. Thus number, letter, and superscript letter designate a particular pollen type.

The introductory portion of the book contains information on collecting pollen, slide preparation, morphology of the pollen grains (following the terminology of Prof. G. Erdtman), and a key to the pollen types, all in Japanese.

Ikuse collected flowers in paper envelopes or glass vials and, at the same time, collected a voucher specimen. Some pollen was obtained from herbarium specimens. Slides were prepared as follows: the dried anther was dissected on a slide in a drop of 95% alcohol. After the alcohol evaporated and the pollen grains were fixed to the slide, the pollen was flooded with xylene or a similar solvent. The pollen was then stained with gentian violet or fuchsin in 95% alcohol, washed with absolute alcohol, and mounted in glycerin jelly. The cover glass was sealed with a balsam-paraffin mixture to prevent evaporation. Pollen measurements from reference slides prepared by this technique may not agree with those of pollen prepared by other methods.

The major portion of the book is divided into systematic studies of which there if first a classification of the flowering plants arranged according to the Engler and Prantl system. This classification is in tabular form with Japanese and English headings, under the following categories: pollen type, sexine pattern, size, date of collection, location, and collector. This section covers 120 pages. The next portion lists for each family the pollen types, sexine pattern, remarks, and size of grains. This is followed by a tabular key to the families and genera and divided into sections based upon the pollen types of figure 2. The tabular heading used are sexine pattern with eight subdesignations, size, remarks, and family or genus. The last key to the family or genus is divided into the six pollen size groups of Erdtman. The tabular headings are size, pollen type, sexine pattern, shape, family or genus, and remarks.

Ikuse includes a floral calendar with the length of the blooming season indicated by a bar graph. The scientific names are arranged by the blooming season from January onward throughout the year. She gives a selected bibliography and two indices, one in Japanese and one to the scientific names.

The first 40 plates are line drawings reproduced at a uniform magnification of 1000× and illustrate the details of 281 species. The last 35 plates are reproductions of 236 photographs which depict 131 species. The magnifications vary from 300 to 2000 times, although most of the pollen photographs are reproduced at 1000×. In these tables Ikuse describes pollen of 2274 species and varieties distributed in 1138 genera and 200 families. Although the author titled the book Pollen Grains of Japan, she also included Taxodium, Sequoia, and several other plants which have been introduced into Japan, thus making the book more complete.

This coverage of the Japanese flora was compared with that in T. Makino's Illustrated Flora of Japan which contains 187 families, 1117 genera, and 2732 species and varieties. Makino lists 47 entities among the Gymnosperms; Ikuse describes 36 and illustrates 13. Makino describes 560 monocotyledonous plants; Ikuse describes the pollen of 422. This comparison, in spite of the discrepancy in numbers, indicates a good coverage of the flora when one considers the lack of distinguishing characteristics in most of the grasses and also among several other families.

The line drawings are easier to interpret than the detailed illustrations of Wodehouse and have more individuality than the palynograms of Erdtman. The photomicrographs are very good, in particular, some of the photographs at the higher magnification which show structural details.

In spite of the Japanese text in the introductory portion, the use of scientific names and the bilingual table headings make this book usable for English-speaking palynologists. Ikuse is to be congratulated for this excellent study which offers possibilities not only for identification of Japanese pollen, but also sets up a scheme which can be used by other palynologists for systematizing the bewildering detail of pollen morphology of any flora. It is possible, by means of several tables, to identify unknown pollen. This same scheme can be used for classification and identification of fossil pollen. This system of tabular description of the pollen is, in many instances, too brief for people who are used to the details of complete, formal descriptions.—CLAIR A. BROWN, Department of Botany, Louisiana State University, Baton Rouge 3, Louisiana.

The Growth of Leaves. Proceedings of the Third Easter School in Agricultural Science, University of Nottingham, 1956. Edited by F. L. Milthorpe. 233 p. Butterworths Scientific publications. London. 1956.

The Third Easter School in Agricultural Science was held at the University of Nottingham in 1956 and is a striking illustration of the effectiveness of a relatively small gathering of scientists concentrating on a specific objective. Americans might well emulate this English custom. The School was organized to explore leaf development from inception to maturity and to demonstrate the relationship between leaf growth and crop yield. This is accomplished through a succinct and refreshing summary of recent developments in the study of the growth of leaves together with reports on current research and a forecast of the direction which investigations are likely to take in the future. Skillful editing and the inclusion of pertinent discussion at the conclusion of each paper made this reviewer feel that he had participated in the conference.

The titles of the papers are especially descriptive and are cited herewith as the most economical way of indicating the wide range of material presented: General aspects of leaf growth by F. G. Gregory; General processes of differentiation by E. Bünning; Growth and cellular differentiation by J. K. Heyes and R. Brown; The inception of leaf primordia by S. W. Wardlaw; Spatial and temporal correlations involved in leaf pattern production at the apex by F. J. Richards; Growth and metabolism in the shoot apex of *Lupinus albus* by N. Sunderland, J. K. Heyes and R. Brown; Morphological aspects of leaf expansion, especially in relation to changes in leaf form by H. Jones; Growth of leaves of an apple rootstock by H. W. B. Barlow and C. R. Hancock; Leaf growth under constant conditions and as influenced by light-dark cycles by E. Bünning; Etiolation phenomena and leaf expansion by W. T. Williams; The relative importance of the different stages of leaf growth in determining the resultant area by F. L. Milthorpe; Influence of light and temperature on leaf growth by G. E. Blackman; Weather and water in the growth of grass by H. L. Penman; and Leaf growth in relation to crop yield by D. J. Watson.

A penetrating discussion of the relationship between leaf growth and yield by D. J. Watson of the Rothamsted Experiment Station climaxed the conference. He emphasized that differences in yield are correlated with leaf area, and that among existing crop varieties further increases in yield will be associated with cultural practices and plant breeding that increase leaf area. The effectiveness of leaf area depends upon the time it appears in the growing season and its location in the life cycle of the plant. For example, in sugar cane and potatoes large leaf area may develop too late in the season to be effective, while in barley leaf area attained before emergence of the inflorescence makes no direct contribution to increased grain yield.

Professor Milthorpe modestly states in the introduction that the treatment of leaf growth is not exhaustive, nevertheless this is the most comprehensive account on the subject to appear in English. Specialists in growth and differentiation, botanists in general, agriculturalists, and graduate students in particular will find this little volume stimulating and rewarding reading. It will serve as an admirable supplement to the usual coursework in morphology and physiology.—M. A. JOHNSON, Professor of Botany, Rutgers.

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INDEX TO AMERICAN BOTANICAL LITERATURE

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TAXONOMY, PHYLOGENY AND FLORISTICS

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